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ENVIRONMENTAL ASSESSMENT FOR THE PROPOSED RE-USE ALTERNATIVES OF GLASGOW AIR FORCE BASE

VOLUME II
APPENDIX E

The Montana Energy and MHD Research and Development Institute, Inc.

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Butte, Montana 59701

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ENVIRONMENTAL ASSESSMENT FOR THE PROPOSED RE-USE ALTERNATIVES OF GLASGOW AIR FORCE BASE

VOLUME II
APPENDIX E

Prepared by

THE MONTANA ENERGY AND MHD
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Prepared for

OLD WEST REGIONAL COMMISSION
Under Contract No. T/717/7230-00/2500

February 1979

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E-1.0--MISCELLANEOUS BACKGROUND MATERIAL

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E-1.0--MISCELLANEOUS BACKGROUND MATERIAL

The subjects detailed in this section include regulations controlling the shipment of goods interstate and between the U.S. and Canada; modular housing materials and factory equipment including costs; wind power calculations for the Glasgow area; coal gasification: selection criteria, capital costs, process economics, and commuter community development at GAFB; and an integrated agricultural facility (IAF), the main feature of which is a gasohol plant.

E-1.1 Freeport Regulation (84-3a RCM, 1977 U.S.-Canada)
E-1.2 Modular Housing Equipment and Specifications (Grizzly Manufacturing, 1978)
E-1.3 Modular Housing Costs (MERDI, 1979)
E-1.4 Wind at Glasgow (MERDI, 1978)
E-1.5 Gasification Process Selection Rationale (MERDI, 1978)
E-1.6 Gasification Capital Costs and Process Economics (MERDI, 1978)
E-1.7 Gasification Plant Commuter Community at Glasgow Air Force Base (MERDI, 1978)
E-1.8 Integrated Agrigultural Facility (MERDI, 1978)

E-1.1--FREEPORT AND FOREIGN TRADE ZONES

There are two distinct tax aspects that are of importance when considering Glasgow Air Force Base re-use:

1) Freeport merchandise exemption, and
2) Foreign Trade Zone designation.

A "freeport" merchandise exemption is a state tax exemption that removes any double or multiple level of tax on personal property stored in one state before shipment to another state or foreign country. Montana is one of 37 states that currently has freeport legislation. This statute is set forth in Section 15-6-202 M.C.A. 1978 as follows:

> "Freeport merchandise exemption. (1) Freeport merchandise is exempt from taxation.
>
> (2) Freeport merchandise means those stocks of merchandise manufactured or produced outside this state which are in transit through this state and consigned to a warehouse or other storage facility, public or private, within this state for storage in transit prior to shipment to a final destination outside the state and which have acquired a taxable status within the state.
>
> (3) Stocks of merchandise do not lose their status as freeport merchandise because while in the storage facility they are assembled, bound, joined, processed, disassembled, divided, cut, broken in bulk, relabeled, or repackaged.
>
> (4) Any person or other group seeking to qualify its property for inclusion in this class shall make application to the department of revenue in such manner or form as may be required by the department.
>
> History: En. Sec. 2, p. 73, L. 1891; re-en. Sec. 3671, Pol. C. 1895; re-en. Sec. 2499, Rev. C. 1907; amd. Sec. 1, Ch. 97, L. 1911; amd. Sec. 1, Ch. 24, L. 1919; re-en. Sec. 1998, R.C.M. 1921; Cal. Pol. C. Secs. 3607 and 3611; amd. Sec. 1, Ch. 98, L. 1931; re-en. Sec. 1998, R.C.M. 1935; amd. Sec. 1, Ch. 85, L. 1965; amd. Sec. 1, Ch. 266, L. 1973; amd. Sec. 1, Ch. 361, L. 1973; amd. Sec. 1, Ch. 376, L. 1974; Clarified Sec. 1, Ch. 8, L. 1975; amd. Sec. 1, Ch. 325, L. 1975; amd. Sec. 1, Ch. 341, L. 1975; amd. Sec. 1, Ch. 442, L. 1975; amd. Sec. 3, Ch. 507, L. 1975; amd. Sec. 7, Ch. 548, L. 1975; amd. Sec. 2, Ch. 52, L. 1977; amd. Sec. 1, Ch. 87, L. 1977; amd. Sec. 2, Ch. 112, L. 1977; amd. Sec. 2, Ch. 126, L. 1977; amd. Sec. 2, Ch. 393, L. 1977; amd. Sec. 1, Ch. 413, L. 1977; amd. Sec. 1, Ch. 492, L. 1977; amd. Sec. 2, Ch. 576, L. 1977; R.C.M. 1947, 84-202(4)."

As can be seen from Sec. 15-6-202 M.C.A., 1978, there are no restrictions on the location or number of facilities within Montana that can obtain a freeport designation. In essence, the whole state of Montana is a freeport.

Foreign Trade Zone designation is concerned with federal customs duties on goods warehoused in the United States. Under certain restrictive conditions as contained in the Code of Federal Regulations (19 CFR 80), an area may obtain Foreign Trade Zone exceptions. This exception permits goods which are imported into the United States (and that will be ultimately exported) to be stored without a double level of taxation in a manner similar to that in which freeport designation allows goods stored in Montana to avoid a double level of personal property tax.

There are some important differences between the two taxation exceptions. A Foreign Trade Zone designation is, in general, restricted to one location per state and is only granted after a facility can meet certain requirements, including demonstrated economic feasibility. The existing GAFB facilities appear to exceed these qualifications with respect to warehouse space, security, and ancillary buildings.

E-1.2--MODULAR HOME MANUFACTURING DATA AND MONTANA APPROVED BUILDING PERMITS

E-1.2.1--Modular Home Manufacturing Equipment, Material, and Specification

Tables E-1.2.1 and E-1.2.2 show typically required items for modular home construction. Table E-1.2.1 lists the equipment and materials necessary for a modular home factory. Approximate costs are also given. Table E-1.2.2 lists the construction materials that would be used in a typical modular home according to present building specificatins. These data were obtained from Grizzly Manufacturing, a modular home builder in Hamilton, Montana.

E-1.2.2--Montana Approved Building Permits

Table E-1.2.3 lists the Montana approved building permits for the years 1977 and 1978. The table delineates permits for family residences including mobile home units.

Table E-1.2.1--Typical Factory Equipment and Materials Used In Modular Home Construction (With Approximate Cost)

Small Tools	$ 1785.00
Routers	277.00
Staple Guns	640.00
Power Saw	22.00
Compressor Air Tank	50.00
Air Compressor	595.00
Air Screw Guns	544.00
Air Gun	181.00
Nailers	792.00
Drafting Tools	125.00
Welder	122.00
2 Jacks	50.00
Stapler and Air Hose	550.00
Welder Amplipher	303.00
Air Drills	60.00
Ladders	64.00
12' Radial Saw	375.00
Scaffolding	1,935.00
Hoists	953.00
Roller Conveyor	120.00
Air Lines	750.00
Glue Guns	868.00
Unisaw and Cover	674.00
Vacuum	100.00
Lumber Stretcher	586.00
Pressure Lines	179.00
Fire Extinguisher	167.00
Fork Lift	2,985.00
Dust Separator	1,566.00
Fires Lines	634.00
Dolly Catts	115.00
Blue Print Machine	1,571.00

Table E-1.2.1--(Continued)

Fire Racks	125.00
Outdoor Electrical Equipment	$ 165.00
Saber Saw	49.95
Underground Equipment	169.44
Transit	200.00
Hydraulic Jacks	106.70
Heaters	802.00

Table E-1.2.2--Typical Modular Home Construction Materials and Specifications

1. Floors:
   - a. 2" x 8" floor joists, 16" o.c., std. and better grade (up to 12' spans).
   - b. 2" x 10" floor joists, 16" o.c. std. and better grade (on 14' spans).
   - c. Reinforced double laminated rim joist system.
   - d. Flooring - 3/4" tongue and grooved exterior plywood glued and nailed to joists and glued on all four edges.

2. Walls:
   - a. 7'6" ceiling height.
   - b. Reinforced double-laminated continuous headers on perimeter walls of each unit half for extra structural strength and for ease in drapery installation.
   - c. Double 2" x 4" top plates on all interior walls, single 2" x 4" bottom plates are standard.
   - d. 2" x 4" studs, 16" on center throughout - stud grade.
   - e. 3/8" CDX plywood intermediate sheathing, glued and nailed.
   - f. Siding is preprimed textured masonite Ruf-X lap as standard.
   - g. Center wall has double 2" x 4" studs, 16" on center set on edge.

3. Roof:
   - a. 3/12 pitched roof.
   - b. 2" x 4" engineered roof trusses, 24" on centers.
   - c. 235 lb. asphalt seal tab shingles over 2 layers of 16 lb. felt and 1/2" exterior plywood sheathing.
   - d. 18" eave and gable overhand.
   - e. Attic is vented with soffit vents and gable vents or roof vents.
   - f. Boxed soffits.

4. Interior Walls and Ceiling Finish:
   - a. 1/2" gypsum drywall on all walls and 5/8" gypsum drywall on ceilings.
   - b. Drywall is screwed to studs.
   - c. Walls are spray-textured and painted.
   - d. Ceilings are spray-textured and painted trowel textured and painted or sprayed (popcorn) effect.
   - e. Kitchen and bathrooms all finished with semi-gloss enamel paint.

5. Insulation:
   - a. 3-1/2" R-11 batts in sidewalls and with vapor barrier.
   - b. 6-1/2" R-19 batts in trussed area of ceiling with vapor barrier.
   - c. 10" R-30 and 12" R-38 are optional.

6. Plumbing:
   - a. Plumbing meets or exceeds FHA and National Plumbing Code requirements.
   - b. 100 lb. pressure tested copper tube water supply system.
   - c. 52 gallon fast-recovery electric water heater.
   - d. PVC plastic drains.

Table E-1.2.2--(Continued)

7. Electrical:
    a. Wiring equals or exceeds the National Electrical Code.
    b. Hall, kitchen sink light and ceiling light, bedroom ceiling lights, dinning room ceiling light and two exterior lights are standard.
    c. Bathroom vent ran on all interior bathrooms.
    d. Electrical box is 200 amp with circuit breakers.
    e. Exterior outlets with ground fault interrupters (GFI).
    f. Bath circuits are protected by GFI.
    g. Smoke detector is standard.
    h. 30" electric range and range hood.
    i. Individual thermostats in each room - wall mounted.

8. Windows:
    a. Horizontal wood sliders with insulated glass and screens.

9. Floor Finish:
    a. Kitchens and baths are heavy guage vinyl.
    b. Carpeting, regular or tweed with 3/8" pad.

10. Doors:
    a. Solid-core exterior doors.
    b. Aluminum storm doors (optional).
    c. Prefinished hollow-core interior doors.
    d. Aluminum patio doors with insulation glass (optional).
    e. Insulated steel entrance systems (optional).

11. Bathroom:
    a. One piece fiberglass tub-shower unit.
    b. Prebuilt vanity cabinet with preformed no-drip counter tops and backsplash.
    c. Porcelain bathroom sinks.

12. Cabinets:
    a. Prebuilt kitchen cabinets with preformed no-drip front and backsplash.

13. Appliances:
    a. Range and hood and double stainless steel sinks are standard.
    b. Garbage disposal and dishwasher (optional).

14. Heating:
    a. Electric baseboard heating system.
    b. Forced air and intertherm hot water baseboard heat (optional).

SOURCE: Grizzly Manufacturing, Hamilton, Montana (November 30, 1978).

Table E-1.2.3--Montana Department of Labor Statistics
Year-To-Date Permit Authorized
Construction in Selected Permit-Issuing Places

1977

	Reported and Imputed			Reported Only			%
	Buildings	Units	Cost	Buildings	Units	Cost	Imputed
001	2415	2415	$70,946,479	2371	2371	$69,629,223	1.8
002	248	496	9,369,074	248	496	9,369,074	.0
003	191	731	11,587,738	191	731	11,587,738	.0
004	92	1315	21,656,934	92	1315	21,656,934	.0
TOTAL	2946	4957	$113,560,225	2902	4913	$112,242,969	.9
300	101	112	1,295,999	101	112	1,295,999	.0
1978							
001	2607	2607	$84,298,147	2524	2524	$82,141,091	3.2
002	196	392	8,575,002	190	380	8,336,283	3.1
003	109	420	8,040,863	106	411	7,882,697	2.1
004	79	993	16,529,486	76	944	15,421,307	4.9
TOTAL	2991	4412	$117,443,498	2896	4259	$113,781,378	3.5
300	87	87	664,101	80	82	664,101	.0

001-One-Family Units
002-Two-Family Units
003-Three- and Four-Family Units
004-5+ Family Units
300-Mobile Homes

E-1.3--MODULAR HOUSING COSTS

In this section of the appendix, an analysis is made to provide an estimate of the additional costs incurred by introducing passive solar heating into the design of a modular home. Because there are no people involved in marketing passive modular homes of the type proposed for manufacture at GAFB, it is difficult to get a clear indication of incremental costs from the market place. One of the leading passive solar architects, David Wright, was quoted recently (Liddle, 1978) as saying that "...Given a reasonable site, I tell my clients I can build a passive house for five to ten percent more than the ordinary house." He was speaking of standard, stick-built housing not modular, but this sets a range. Wright also cautions that his concept of an "ordinary house is one with good heat-retention characteristics to begin with; good insulation, good glazing, etc. Since a good envelope or 'weatherskin' is the basis of a good passive solar home and because most modular home builders now offer an energy conserving option, I am assuming for the purposes of this discussion that the incremental cost of passive solar will be that over and above the cost of bringing the building envelope up to more current energy-conscious levels of insulation."

The approach taken here, therefore, was to estimate the performance of a realistic passive solar design, estimate the probable savings, and set a range on cost (Balcomb and McFarland, 1978; Noll, 1978; and Adams, 1979).

In the work sheets attached, which were derived from Balcomb and McFarland (1978), the probable performance versus size characteristics of a water wall, a water wall with night insulation, a Trombe wall, and a Trombe wall with night insulation, for two levels of performance are listed. A water wall was chosen for this discussion based on the assumption that a modular home builder would opt for water rather than masonry or concrete to provide thermal mass. By doing so, he could avoid costly on-site formwork for concrete and/or the high cost of both transportation of concrete masonry units and the masons to lay them. In other words, by choosing one of several presently available water containerization methods, he could ship empty containers to the site, set them up, and fill them with water--saving both transportation and labor costs. Also, from data derived by Balcomb and McFarland, some calculations of a similarly sized and constructed but non-solar house can be made.

Taking one case only, the assumptions made about the house and the corresponding heat loss/energy consumption result in an estimate that a 1,200 square foot residence with a 224 square foot water wall utilizing nighttime insulation and electric resistance auxiliary heat would result in an annual savings of $345 relative to an electrically heated non-solar house whose occupants paid 2.5¢ per kilowatt hour or an annual savings of $552 if they pay 4.0¢ per kilowatt hour.

It should be emphasized that these figures assume comparison with an all-electric, non-solar house. The actual savings due to and, hence, the advisability of investing in the solar wall will decrease significantly if other less expensive conventional fuels are used. In other words, the less expensive the conventional fuel, the less rationale there would be for making the solar investment. Of course, conventional fuels will not go down in price, but any builder contemplating solar must take into account the significant effect that low conventional fuel prices can have on the economics of solar investment.

A probable cost for the hypotehtical example was derived from Noll, 1978 and Adams, 1979, and it appears that one could defend about $3.00 per square foot of residence for the incremental cost of the solar wall over the standard house (see the attached work sheets). Although this appears to check well with Wright's 5 to 10 percent, one must remember that his houses usually were closer to $50 per square foot than $27. Further caution is in order in using this figure, i.e., it probably is low.

A. The "standard house" cost of $27 per square foot does not include land, site preparation, and foundation costs. It is probable that these would be greater for a passive solar home than for a conventional home because site requirements (i.e.,

---

*Kalwall's Solar Storage Tubes, Design One's fiberglass bins, corrugated culvert pipe or even 55-gallon drums.

a southern exposure) are more strict; more earthwork (i.e., beaming, etc.) is likely to be encountered; and heavier foundations (i.e., to support the mass wall) will be required.

B. The construction techniques and level of craftsmanship required in a solar home are likely to be somewhat costlier than, if not at least different from, that found in most standard modular construction at present. It is unknown what potential problems a builder might face in adapting his modular assembly line to solar construction, but there will be a quantifiable cost involved in doing so.

C. Solar construction can and does present special problems in material availability, and some of the requirements and materials involved have special transportation and handling problems of their own and, therefore, another quantifiable cost. (Noll's costs are based on 1978 dollars in Albuquerque; costs in Glasgow in 1979 can be expected to differ from them.)

D. The economics of scale will have a great deal to do with the incremental cost of "modular solar" over "regular modular;" whatever reserach and development, re-jigging, and/or retraining of workmen that is involved in adapting the modular product to the solar market will contribute a cost and one which will vary per unit depending on how many (and how many different types of) units are built. Obviously, the same can be said relative to quantity buying of special material like glazing and water storage containers also.

E. It is likely that the Albuquerque figures would be increased somewhat by features necessary on the "high line" in Montana that would not be required in New Mexico: higher R-value insulation at night, for example, or triple rather than just double glazing, both of which may be required to achieve adequate performance in Montana's more severe climate.

PASSIVE/MODULAR WORK SHEETS

PART I. PERFORMANCE AND SIZING

STEP 1. DERIVE BUILDING LOSS COEFFICIENT IN Btu/DD

Assumptions: 1,200 square foot house, R-38 ceiling, R-20 walls, raised floor (R-20), 20 percent wall area in double glazed windows (excluding south wall), built tight (1/2 air change per hour).

Conductance =

Roof: .026 x (30 x 40) = 31.6 Btu/^{o}F
Floor: .05 x (30 x 40) = 60 Btu/^{o}F
Walls: .05 x (.8)(8)(100) = 32 Btu/^{o}F
Windows: .5 x (160) = 80 Btu/^{o}F
204 Btu/^{o}F

Infiltration: (.5)(.075)(9600)(.24) - 86 Btu/^{o}F

TOTAL 290 Btu/^{o}F

Total hourly loss/^{o}F x 24 = Building Loss Coefficient in Btu/DD.
290 x 24 = 6960 Btu/DD

STEP 2. EXPRESS THE BUILDING LOAD COLLECTOR RATIO

$$\text{i.e.,}\quad \frac{\text{Building Loss Coefficient}}{\text{Solar Collection Area (ft}^2} = \frac{6960}{x}$$

where "x" would be the area of collection required to give the following ratios for 50 percent and 60¢ solar heating fraction (from Balcomb and McFarland, Table 1).

Glasgow, 8996 Degree Days, 48 N. Latitude

Solar Heating Fraction:	.5	.6
Water Wall	19	12
Water Wall w/Night Insulation	41	31
Trombe Wall	19	12
Trombe Wall w/Night Insulation	39	29

From this information can be interpolated an area of "collector" required to give the following performances (SHF) for each of the following configurations;

For .50 solar heating fraction:

$19 = \frac{6960}{x}$, x = 366 sq. ft. water wall

$41 = \frac{6960}{x}$, x = 169 sq. ft. water wall w/night insulation

$19 = \frac{6960}{x}$, x = 366 sq. ft. Trombe wall

$39 = \frac{6960}{x}$, x = 178 wq. ft. Trombe wall w/night insulation

For .60 solar heating fraction:

$12 = \frac{6960}{x}$, x = 580 sq. ft. water wall

$31 = \frac{6960}{x}$, x = 224 sq. ft. water wall w/night insulation

$12 = \frac{6960}{x}$, x = 580 sq. ft. Trombe wall

$29 = \frac{6960}{x}$, x = 240 sq. ft. Trombe wall w/night insulation

NOTE: The "Solar Heating Fraction" used above (SHF) can be ambiguous when applied to a passive solar building (i.e., What are we comparing the building with?). As used herein, the SHF is the fraction of the degree day load which is supplied by the solar wall.

NON-SOLAR BUILDING

Conductance Losses:

Roof: .026 (30 x 40) = 31.6 Btu/^{o}F
Floor: .05 (30 x 40) = 60 Btu/^{o}F
Walls: .05 (.8)(8)(140) = 44.8 Btu/^{o}F
Windows: .5 (224) = 112 Btu/^{o}F
248 Btu/^{o}F

Infiltration: (.5)(.075)(9600)(.24) = 86 Btu/^{o}F
TOTAL 334 Btu/^{o}F

Total Hourly Loss/^{o}F x 24 = Building Loss in Btu/Degree Day

334 x 35 = 8016 Btu/DD

For Glasgow (8996 Degree Days), the annual space heating load would be

(8996)(8016) = 72.1 Btu x 10^6

For a building with a solar wall sized to provide a Solar Heating Fraction of .5, the auxiliary used would be

(1 - SHF) (Annual Heating) (Building Loss)
(Degree Days) (Coefficient)
(Btu/Degree Day)

or

(1-.5) (8996) (6960) = (.5) (62.6 x 10^6 Btu/yr)
= 31.3 x 10^6 Btu/yr auxiliary required

For a wall sized to provide an SHF of .6, the figure for auxiliary would be

(.4) (62.6 x 10^6 Btu/yr)

or

25.04 x 10^6 Btu/yr auxiliary required

SOLAR-WALLED HOUSE COST COMPARISON TO NON-SOLAR HOUSE

	Non-Solar	Solar, SHF=.5	Solar, SHF=.6
Energy Required (Btu x 10^6/yr)	72.1	31.3	25.04
Energy not Pruchased vs. Non-Solar House (Btu x 10^6/yr)	-0-	40.8	47.1
Amount of Energy not Purchased (Btu x 10^6/yr) (savings), assuming electric resistance heat (kWh = 3413 Btu)	-0-	11,954	13,800
Energy Purchased (kWh/yr)	21,125	9,170	7,336
Probable Cost/yr if a kWh costs 2.54[1]	$528.13	$229.25	$183.40
Probable Cost/yr if a kWh costs 4¢[2]	$845.00	$366.80	$293.44
$ Savings, Solar vs. Standard Non-Solar			
at 2.5%/kWh	-0-	$298.88	$344.73
At 4¢/kWh	-0-	$478.20	$551.66

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[1] Montana Power Company's kWh cost - 2.5¢.

[2] Assumed higher electrical cost provided for comparison.

PART 2. COST

Noll's economic analysis of passive design deals with a Trombe mass wall rather than a water wall, but his figures indicate that the incremental cost of a concrete Trombe wall with night insulation is $14.61 per square foot of wall. This figure includes the wall with supporting foundation, vents, header trim or overhang, glazing, framing, and the night insulation option, as well as a credit of $2.10 per square foot for replacement of the conventional wood-framed south wall that the solar wall replaces.

Applying these figures to the 240 square foot Trombe wall (with night insulation) required to provide a .6 Solar Heating Graction in the example, the incremental cost is set at $3506. This would translate to a cost of $2.92 square foot of residence. If a modular manufacturer were able to produce units at a cost of $27 per square foot, for example, and could add the wall mentioned for a cost of $2.92 per square foot, the 1,200 square foot unit in question would sell for about $30.00 per square foot. The solar option would then account for about 10 percent of the total cost. This agrees with Wright's calculations and is probably reasonable. Water wall costs were projected from $12 to $15 per square foot of wall, setting the fairly wide range of 30 to 70 percent of heating requirements as probable performance (Adams, 1979).

E-1.4--WIND AT GLASGOW

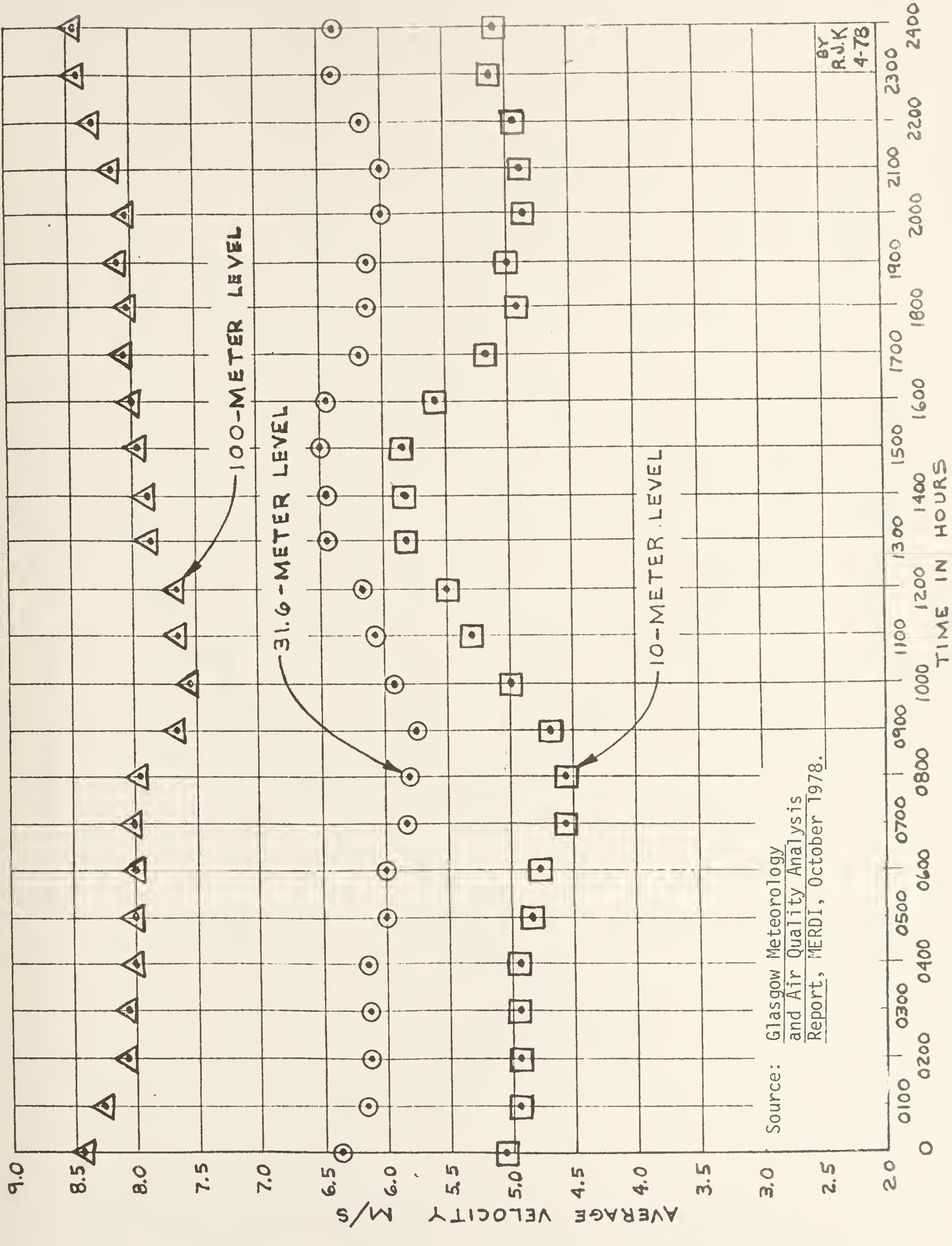
E-1.4.1--Introduction

During the one-year period from October 25, 1977 through October 25, 1978 MERDI monitored wind speed and direction at GAFB. The measurements were made using a 100-meter tower with recording instrumentation located at the 10-meter, 31.6-meter, and 100-meter levels. Wind speed and direction were acquired at 0.6-second intervals and recorded as 10-minute integrations during the entire year.

Figure E-1.4.1a is a plot of the average hourly wind velocities measured at three levels during the period of October 25, 1977 through March 1978. Figures E-1.4.2a, E-1.4.2.b, and E-1.4.2.c, show wind speed frequency distribution at the 3 tower levels. These plots indicate sufficient wind potential for at least partial generation at each level. The wind volocities recorded at the 100-meter level consistently averaged 7.5 meters per second or 16.7 miles per hour (mph) to 8.5 meters per second or 19.0 mph. The raw data are contained on computer print-out sheets which are available at MERDI's offices in Butte, Montana. A separate report (MERDI 1978) detailing and analyzing the meteorological and air quality data collected for one complete year has been issued by MERDI.

Additional wind data for Montana were obtained from a Sandia Laboratories report which tabulated and analyzed national wind data (Sandia Laboratories 1977). These data were collected at various National Weather Service Stations around the country, usually located at airports. Figure E-1.4.3 is a graph from the Sandia report depicting the monthly power available from the wind at four cities in Montana. The plots show two types of wind regimes in Montana. Livingston and Whitehall are characteristic of the western mountain area with high winter winds and low summer winds. Glasgow and Wolf Point are more characteristic of the eastern plains area with lower and fairly constant winds.

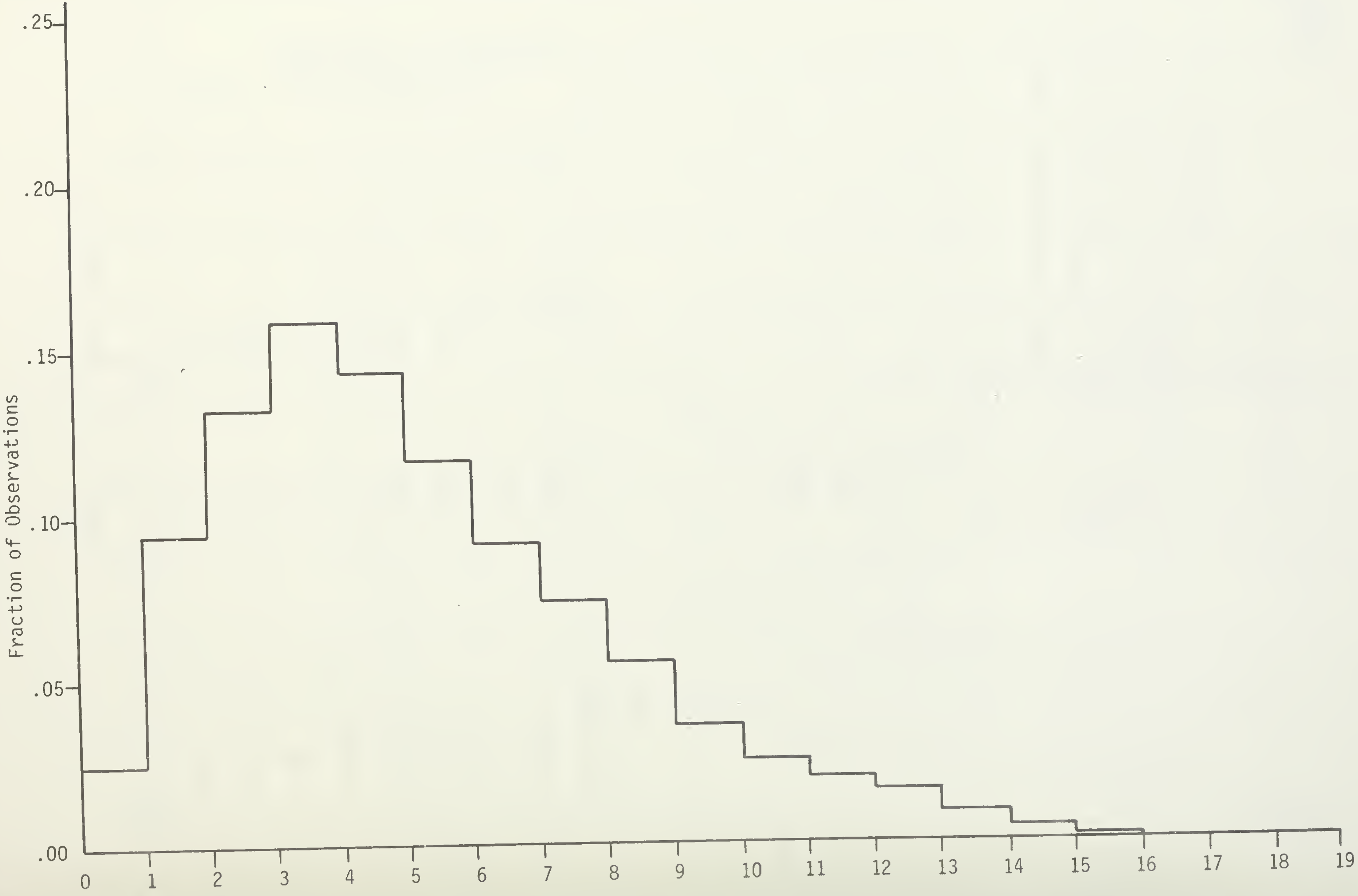
AVERAGE HOURLY WIND VELOCITY AT GLASGOW A.F.B., MT., 10-25-77 TO 3-78.



Source: Glasgow Meteorology and Air Quality Analysis Report, MERDI, October 1978.

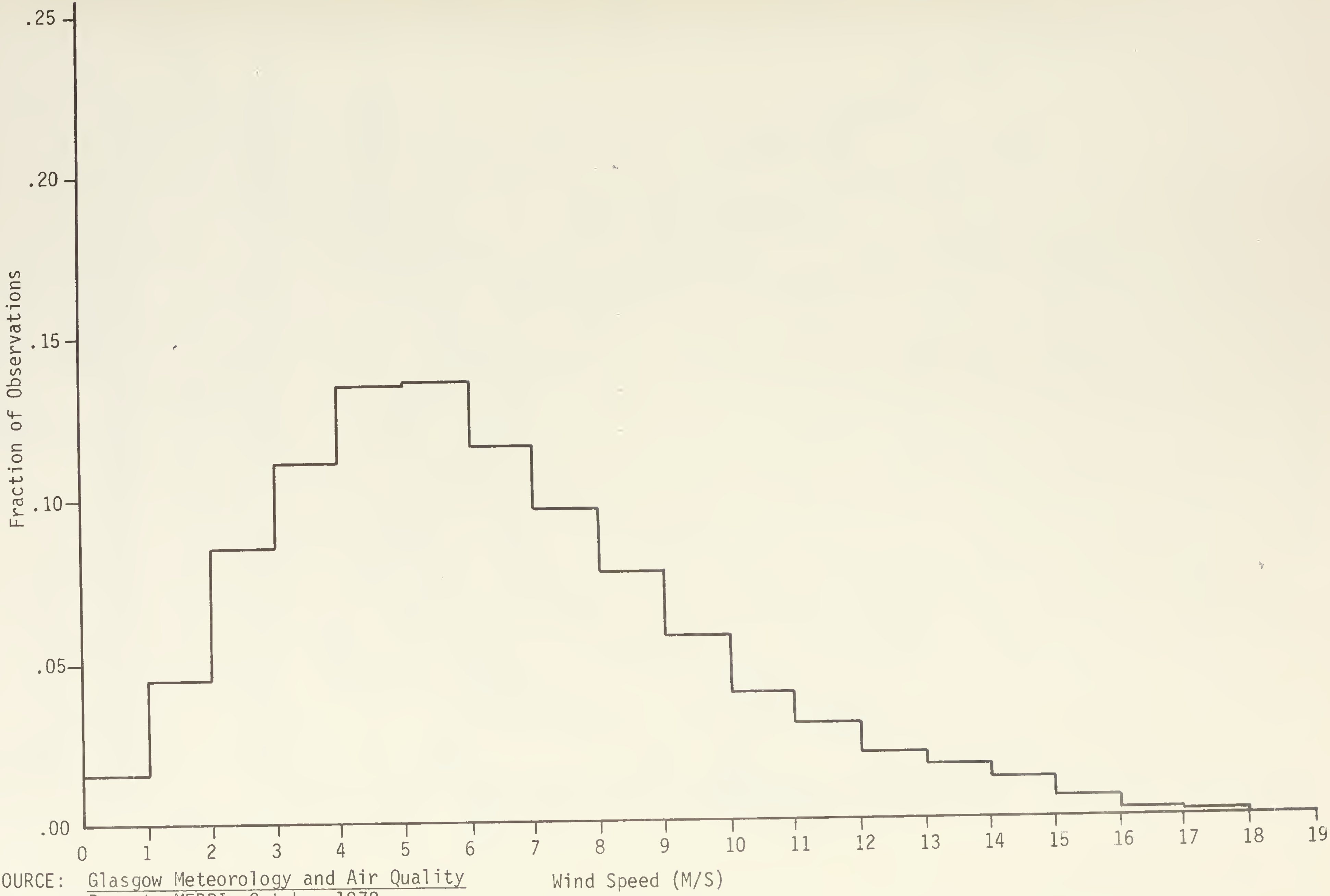
Figure-- E-1.4.1a

Figure E-1.4.2a--Wind Speed Frequency Distribution Ten-Meter



SOURCE: Glasgow Meteorology and Air Quality Report, MERDI, October 1978.

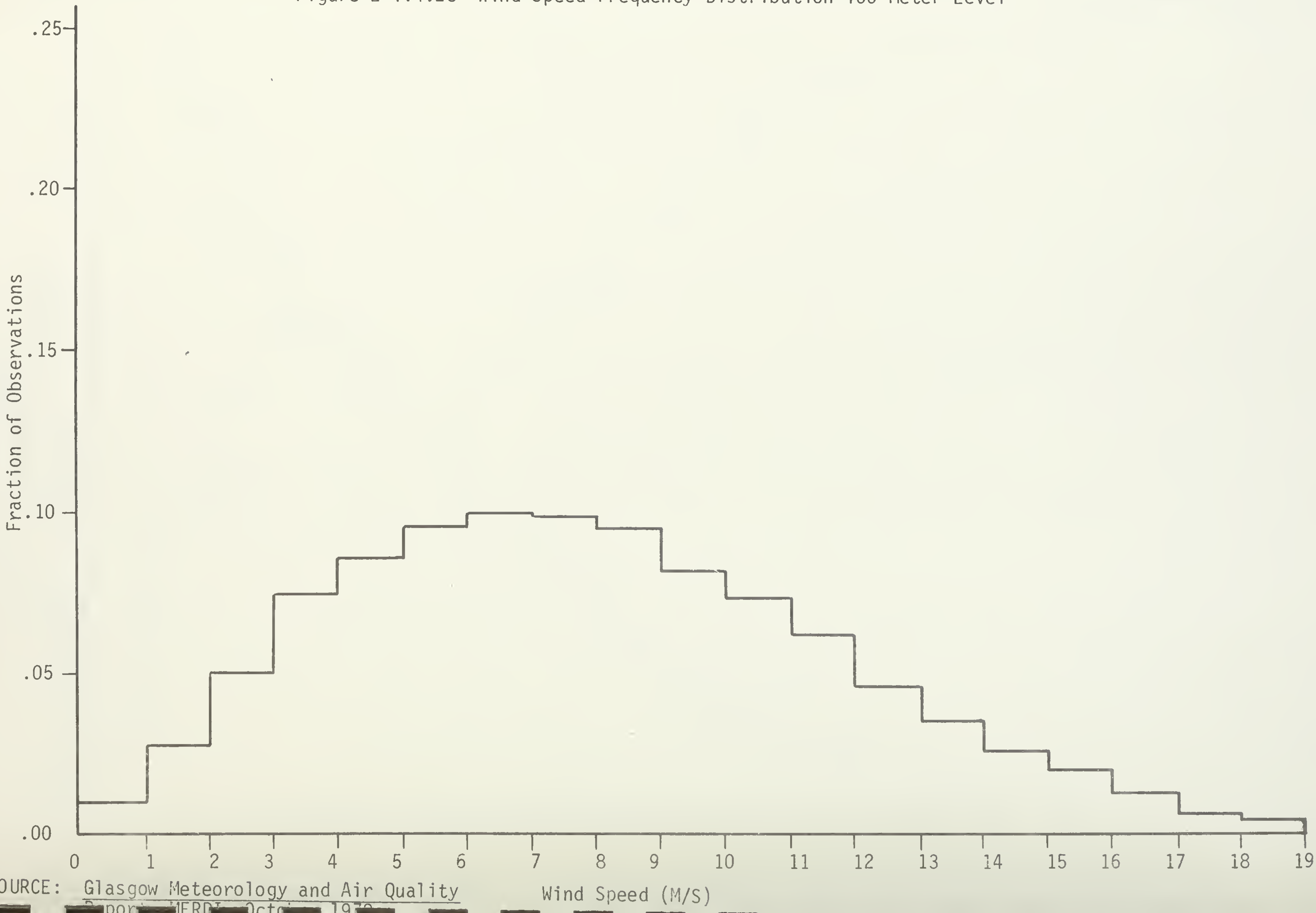
Figure E-1.4.2b--Wind Speed Frequency Distribution 31.6-Meter Level



SOURCE: Glasgow Meteorology and Air Quality Report, MERDI, October 1978.

10-10-78 21-000-082-A

Figure E-1.4.2c--Wind Speed Frequency Distribution 100-Meter Level



SOURCE: Glasgow Meteorology and Air Quality
Report, MERDI, Octo[illegible] 197

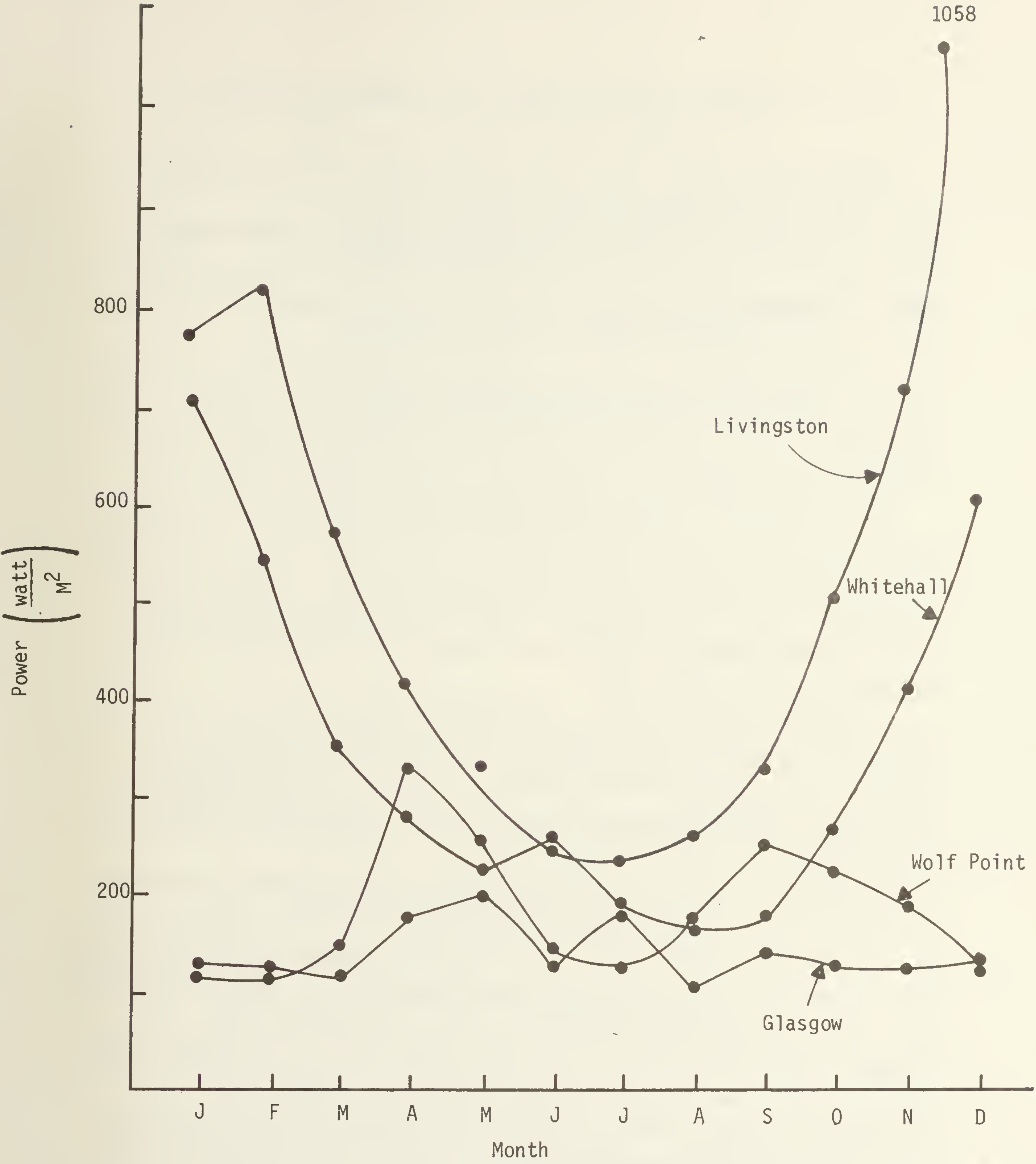


Figure E-1.4.3--Monthly Average Power Available for Selected Sites in Montana - National Wind Data Analysis By Sandia Laboratory

E-1.5--RATIONALE FOR COAL GASIFICATION PROCESS SELECTION

To determine the most suitable gasification technology for the study area, numerous existing processes must be evaluated in light of their respective technical and economic factors. In addition, process-specific impacts must be reviewed for their compatibility with existing state and federal environmental legislation, e.g., siting requirements, air and water pollution standards, etc.

In 1976, the Dravo Corporation performed a two-phase screening of 21 processes (eight of which were considered in detail) for the Montana Trade Commission. The analyses were predicated upon the plant design and coal characteristics specified in Tables E-1.5.1 and E.1.5.2, respectively.

The 21 potential process types were initially examined in accordance with the various primary criteria given in Table E-1.5.3. The eight technologies judged to pass this test then were evaluated via application of the second criteria also present in Table E-1.5.2. The five processes with the highest overall ratings were chosen for further consideration and are briefly discussed below.

Inspection of the technical evaluation ratings in Table E-1.5.4 shows that the Lurgi, Koppers-Totzek, and Winkler processes rank the highest. This is to be expected since all three are first-generation, commercially utilized processes; their respective operational schemes do differ, however, as shown in Table E-1.5.5.

The Lurgi fixed-bed process is the culmination of efforts initiated in Frankfurt, West Germany about 40 years ago. Since that time, more than 58 units have been built in Europe and elsewhere (except the United States); the largest installation is comprised of 13 gasifiers at the Sasol synthesis plant in Sasolburg, South Africa. The Koppers-Totzek (KT) process was originally created through the cooperative efforts of Dr. F. Totzek, Essen, Germany, and an American subsidiary of the Koppers Company, Inc., of Pensylvania in 1948. Although there are at least 50 KT plants operating around the world, no commercial facility exists in the U.S. despite past Bureau of Mines efforts at their pilot plant sited near Louisana, Missouri.

Table E-1.5.1--Plant Design Specifications

- 150 mmscfd SNG (925 Btu/scf, HHV, dry)
- Ammonia synthesis gas equivalent to 1000 tpd anhydrous ammonia
- Maximum SNG moisture content of 7 lbs/mmscf and delivered into pipelines operating at 1000 psig
- Operation to be designed on a "grass roots (up)" basis, with the assumed site being GAFB

Source: Dravo Corporation, p. 2-2

Table E-1.5.2--Montana Lignite Specifications

Type: Circle West Lignite, "R" Bed

Mine Location: 40 miles S/SE of GAFB

Sized, As Received: Approximately 2" in diameter, washed

Percent Moisture: 35.02%, as received

Ash: 6.86%, as received

Heating Value: 6,894 Btu/lb., as received
10,610 Btu/lb., dried

Source: Dravo Corporation, p. 2-3.

Table E-1.5.3--Primary and Secondary Processes Screening Criteria

Primary

- Montana schedule requirements must be met, i.e., the process must have been demonstrated on either a commercial or semi-works pilot-plant scale, and

- the gasifier must be operable on Montana lignite or operating experience must be available on physiochemically similar coal types.

Secondary

- overall thermal efficiencies

- ease in preparation of engineering, procurement, and construction schedules

- qualitative evaluation for suitability to Montana lignite coal, degree of development, technical risk, mechanical reliability, operability and startup, flexibility and turndown, gasifier scale-up requirements and environmental considerations, and

- assessment of the economic viability of the processes, and estimation of capital investments and operating costs (including startup, working capital, manpower requirements, supplies, and overhead costs.

Source: Dravo Corporation, pp. 2-3, 2-4.

Table E-1.5.4

PROCESS SELECTION STUDY
SNG FROM COAL
FOR
MONTANA TRADE COMMISSION

SUMMARY OF EVALUATION

	BABCOCK & WILCOX	CO_2 ACCEPTOR	COGAS	HYGAS	KOPPERS-TOTZEK	TEXACO	WINKLER	LURGI
Raw Coal, TPD	21,614	17,946	29,600	21,434	23,079	22,029	22,603	22,425 ***
Oxygen, TPD	11,622	--	--	2,229	11,736	10,318	5,266	3,590 ***
Raw Water, GPM	19,476	5,847	14,689	7,121	18,189	17,356	17,877	6,080 ***
Purchased Electric Power, KW	297,200	90,100	48,700	91,200	435,200	120,500	189,900	58,000 ***
Total Plant Investment, $MM	807.8	469.8	740.9	454.6	874.6	746.6	697.2	500.0 *
Gas Cost, $/MM BTU	5.55	3.08	4.13	2.62	5.89	4.79	4.73	3.11
Overall Thermal Efficiency, %	44.7	64.8	58.1	69.8	42.2	52.0	50.8	60.1**
Technical Evaluation Ratings (Top Rating = 75)	55	45	43	45	70	42	65	72
Overall Evaluation Ratings (Top Rating = 80)	44	60	51	64	46	48	55	65

* Value derived by deleting the NH_3 synthesis section from the Lummus Estimate.

** Value derived from Lummus Estimate by substituting for purchased power a coal equivalent of 10,000 BTU/KWH instead of heat equivalent of 3413 BTU/KWH.

*** Lurgi/Lummus Estimate

SOURCE: Dravo Corporation.

Table E-1.5.5--Coal Gasification Processes for the Commercial Production of High-Btu Gas

Process	Reactor Bed Type	Gasifying Medium	Residue Type	Pressure a)	Temperature b)	Capacity c
Lurgi	Fixed	oxygen-steam	dry ash	30-50	500-800 (top) <2,000 (bottom)	1000
Koppers-Totzek	Entrained	oxygen or limited oxygen-steam	dry ash	1	1,750-2,350	850
Winkler	Fluidized	oxygen-steam or air-steam	dry ash	1	1,500-1,800	100

a) in atmospheres; b) in degrees Fahrenheit; c) in tons input per day

Source: Harry Perry "Coal Conversion Technology", Chemical Engineering, July 22, 1974, pp. 88-102; above data taken from Table 1, p. 90.

Note: More detailed process descriptions for these technologies can be found in Appendices B, C, and D (respectively) in Volume 5 of MERDI Site Suitability Analysis of Glasgow Air Force Base, Montana, for an Energy Park, prepared for the Federal Energy Administration, Washington, D.C., July 1975.

It appears that KT facilities are more pollution free, more efficient in coal stock utilization, and quicker to construct that the equivalent Lurgi operation; however, the former does have a lower overall thermal efficiency (owing to fewer "energetic" by-products like tar oils, naphtha, and crude phenols) and also exhibits higher economic sensitivities to the rank of coal used.

The first commercial Winkler gasifier was put into operation at Leuna, Germany in 1926. The process has been utilized in at least 16 plants (with at least 36 generators) throughout the world.

The results of the Dravo overall process evaluation of the HYGAS and CO_2-Acceptor technologies indicate some promise for future application(s) because of their relatively high thermal efficiencies and potential low gas production costs. Brief process summaries of these two second-generation, small-scale demonstration installations are given in Table E-1.5.6.

A three-ton per hour HYGAS pilot plant located near Chicago, Illinois has been operated successfully on lignite coal sources and electrothermally generated hydrogen since 1974. Conoco Coal Development Company (formerly Consolidation Coal) has operated a three-ton per hour design capacity lignite-fired CO_2-Acceptor pilot plant near Rapid City, South Dakota since 1972 with satisfactory results (at 42 percent load factor).

As seen in Table E-1.5.4, the closeness in the overall ratings for the Lurgi, HYGAS and CO_2-Acceptor processes disallows a definitive selection of a particular technology for use at GAFB. Thus, as recommended by Dravo personnel, the commercially mature, low technical risk Lurgi process (with its relatively high overall thermal efficiency rating, low SNG cost, and ease in scaling modifications) will be selected for this assessment document considerations. Finally, the Lurgi technology can be modified to recover approximately 80 percent of the coal feedstock's original nitrogen content via production of compressed, anhydrous ammonia. This material can then be utilized as feedstock in the agricultural fertilizer processes potentially located at GAFB or elsewhere as determined by economic constraints.

Table E-1.5.6--Potential Commercially Viable Second-Generation Gasification Processes

Process	Reactor Bed Type	Gasifying Medium	Residue Type	Pressure$^{a)}$	Temperature$^{b)}$	Capacity^{c}
HYGAS	Fluidized	Hydrogen from Hydrogasifier Unit	Dry char	75-100	1,200-1,500 1st stage 1,700-1,800 2nd stage	80
CO_2-Acceptor	Fluidized	Air in the regenerator, steam in the gasifier	Dry char & spent dolomite	10-20	1,575	30

a) in atmospheres; b) in degrees Fahrenheit; c) in tons per day

Source: Dravo Corporation

NOTE: More detailed process descriptions for these technologies can be found in Appendices F and E (respectively) in Site Suitability Analyses at Glasgow Air Force Base, Montana for an Energy Park Prepared for the FEA, Washington, D.C. July 1975.

E-1.6--DETAILED CAPITAL COSTS FOR LURGI COAL GASIFICATION PLANT

A detailed list of the Lurgi coal gasification plant components and their contribution to the total capital requirement for plant construction is shown in Table E-1.6.1. These cost estimates were obtained from results of the Lummis cooperation study made for the Montana Trade Commission report in 1976. This document is referenced in the main body of the text (MTC 1976). The estimates shown in Table E-1.6.1 were adjusted by the Andy Whitman Public Utilities price index to reflect 1978 prices.

Table E-1.6.1--Capital Costs For Lurgi Coal Gasification Plant

Plant Component	Cost Estimate MM $
Gasification	97.7
Shift Conversion	14.4
SNG Gas Cooling	
Rectisol	8.5
Phensolvan and NH_3 Recovery	45.9
Methanation	24.1
Gas Liquor Separation	9.4
Product Gas Compression and Drying	10.8
Coal Preparation and Handling	52.5
Air Separation Unit	57.1
Sulfur Recovery	16.5
Steam Generation and Distribution	91.4
Stack Gas Scrubbing	23.1
Raw Water Supply and Treating	17.4
Cooling Water	12.1
Fire Protection System	.9
Miscellaneous Utilities	.9
Offsite Storage and Loading Facilities	5.0
Plant Interconnecting Piping	10.2
Liquid Waste Effluent System	4.7
Ash Disposal	3.7
Flare System	2.8
Offsite	27.4
Project Contingency + General Administrative Expense + Engineering Supervision	(Included in Total)
TOTAL PLANT INVESTMENT	565.0

Source: Montana Trade Commission, 1976.

E-1.7--COMMUTER COMMUNITY

E-1.7.1 Summary

Three modes of travel were examined for potential use as connecting links between existing housing at Glasgow AFB and proposed Lurgi gasification plant construction site, and four options for temporary housing at the construction site were examined. A fifth option, temporary single-family detached housing at the site, was examined briefly.

Housing costs at the site, except for single-family homes, were based on the experience of Colstrip electric plants #1 and #2 constructed in early 1970. All single-family housing at Colstrip was intended to house the permanent work force after use by construction workers, hence it was larger and more expensive than would be practical for temporary use.

Results of the study indicate that the major determinant of cost-effectiveness of the on-base option is the need to pay construction workers travel time. The least expensive transportation solution (bussing the workers) requires nearly 4½ hours per day of travel for each worker. Acceptance of such a time penalty without pay is unlikely. If as much as straight-time pay is required, air travel is the least expensive mode. However, with very specific and limited exceptions, on-base housing plus air transport is not competitive with on-site housing.

The most important exception is that family housing could be provided at the base opposed to bachelor camps at the site. The additional cost of on-base, family housing is less than $2,000 per worker per year provided that the workers do not require payment for travel time. Experience at Colstrip indicates that many married workers lived in bachelor camps at the site during the work week, then commuted long distances to be with their families on the weekends. If workers are willing to travel without pay for travel time in return for the opportunity to be with their families every night and if the costs up to $2,000 per worker can provide a more stable and productive work force, then this option should be examined in more detail.

It should be noted that costs of base housing to the company and rent paid by the workers could not be estimated. It is quite possible that a trade-off with workers between very low rents and no travel pay would make the on-base housing slightly less expensive to the company.

The other exception also concerns family housing. If single-family housing must be provided for some reason, it would be less expensive to use the facilities at Glasgow AFB because construction period housing needs exceed the housing needs of the permanent work force.

E-1.7.2 Construction Worker Housing

The following paragraphs present the trade-offs between the major methods of housing workers during a four-year construction period near Circle, Montana. Those major options are

1) In newly constructed housing (permanent and temporary) near the construction site; and
2) In existing vacant housing at Glasgow AFB.

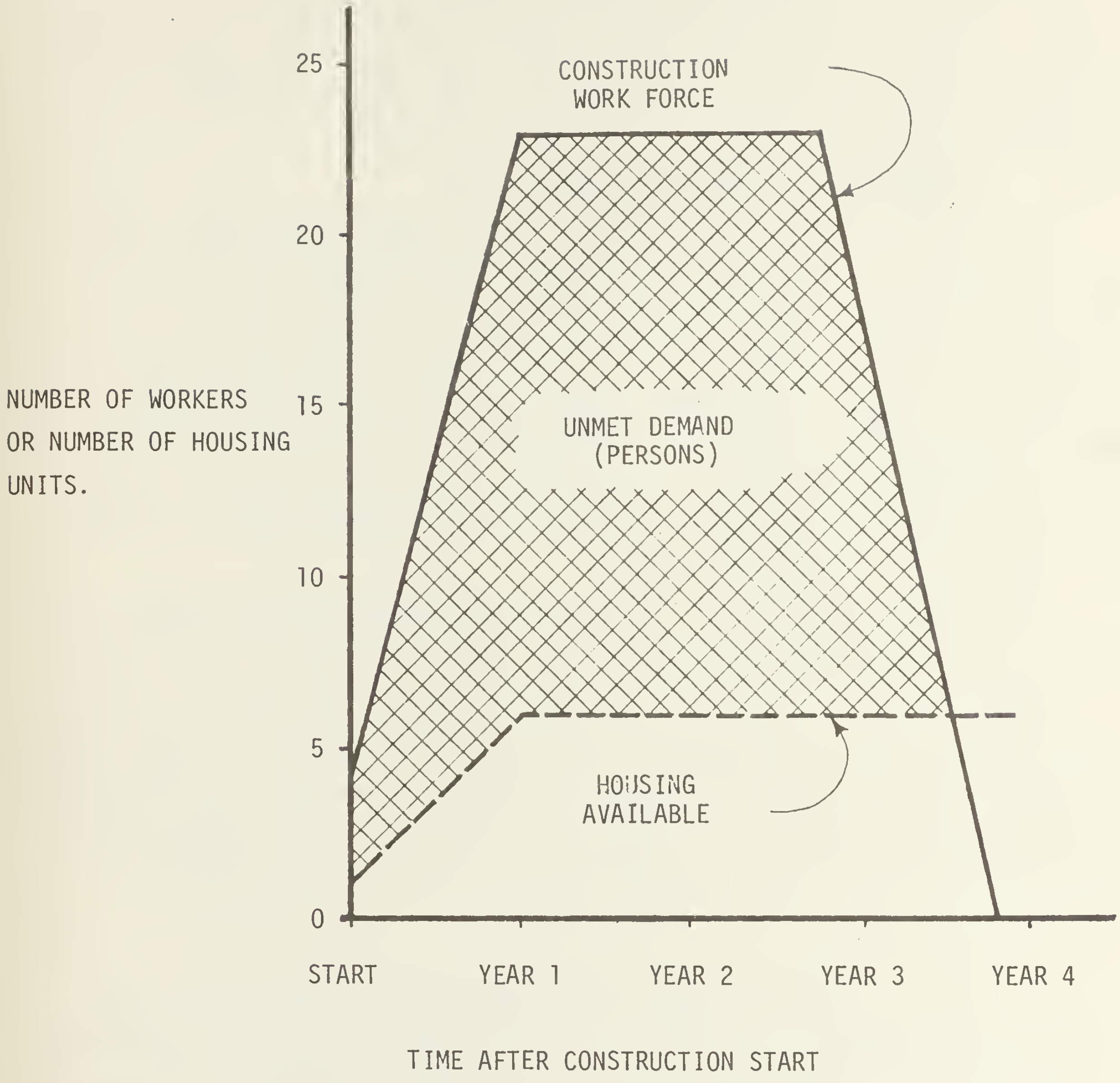
The latter will require installation of a high-speed transportation system between the base housing and the plant site.

Prior to the selection of these two options for detailed study, surveys indicated that dependence upon local resources is impractical. The population of Cirlce is less than 1,000 persons. Three of the four towns within a 50-mile radius of Circle have populations of less than 100 persons; the fourth is under 400. In contrast to the peak work force of 2,300, it is probable that existing local resources can supply housing for only about 100 people.

The permanent plant work force will total about 600 persons. It is expected that existing housing, privately developed new housing, and company-developed new housing will meet the needs of these 600 families. It is reasonable to assume that these 600 units can be made available for use by workers during the construction period. Addition of this permanent work force of 600 will create additional employment in retailing and other services in the area, but this additional employment and the parallel housing developments are expected to be in balance and are excluded from this analysis.

The problem is illustrated in Figure E-1.7.1; housing needs will exceed supply by 1,700 workers with a duration of the peak of just over two years. Sufficient housing to meet this requirement appears to be available at Glasgow AFB as follows:

Dormitories	1,780 beds
Bachelor Officer Quarters	85 units
Family Housing	1,227 units
Total	3,092



Note: Maximum housing available equals requirement of permanent work force.

Figure E-1.7.1--Housing Requirement Construction Period

Construction of these facilities was completed in 1958 or later, and all services--including mess halls and service dormitories--are available.

The major cost of using this housing will be for transporting workers to the plant site, a distance of 120 miles. The major alternative is, as stated, new construction. These alternatives and their costs are treated in the following two sections. Because they are not mutually exclusive, possible combinations are discussed in the third section.

E-1.7.3 Transportation For Glasgow AFB Housing

The transportation option contains a large number of variables, many of which cannot be determined at this time. However, several analyses are available which can show the extent of the problem. Three modes of transportation are available--bus, rail, and air--and each mode requires expenditures for capital investment, operating costs, and worker wages. Note that the worker wages are for those workers who would be transported; it is assumed that construction trade workers would not spend 2 to 4 hours traveling per day without pay. The wages of the transport system operators are included in the operating costs.

First-order costs of the three potential modes are given in Table E-1.7.1. With the inclusion of worker wages, the air mode is clearly least expensive.

Table E-1.7.1 data are based on transporting all of the workers identified in Figure E-1.7.1 to the site in the morning and back to the base in the evening (a single day shift). Substantial economic savings are available if multiple shifts are used. For example, 23 airplanes are required to serve a single shift, while only 9 are required to serve three equal shifts. The savings in capital cost is $4.2 million.

A. Bus On Highway

The bus analysis assumes the purchase of new units of the type produced by Motor Coach Industries in Pembina, North Dakota which are used by major commercial operators. Ten percent spares are included. Salvage value after four years and 150,000 miles per bus is assumed to be 75 percent of the purchase price. This optimistic assumption is offset by the fact that not all of the units will be needed for the entire period; some can be retired after as little as two years of service and 75,000 miles.

As shown in Table 1.7.1, the major drawback to the busing is the long travel time which would result in higher worker wage costs.

Table E-1.7.1--Transportation Costs
(4 Years, $ Million)

	BUS	RAIL	AIR
Capital Investment	5.0	145.0[1]	9.3
Operating Cost	4.3	4.3[1]	18.2
Worker Wage Cost[3]	67.9	34.0	24.3
Subtotal	77.2	183.3	51.8
Salvage Value (10% int)	2.0	17.1[2]	4.7
TOTAL	75.2	166.2	47.1

---

[1] These are very rough and optimistic values.

[2] Salvage value for rail assumes that no substantial economic use can be made of track (guideway) after the construction period.

[3] This as a $12 per hour average rate with a 35% burden. Questions of premium time are not addressed here.

While significant time reductions would be available with cruise speeds above the 55 mph limit, assuming higher speeds is not realistic.

B. High-Speed Tracked Vehicle

Conventional rail is used as representative of self-propelled vehicles/systems on a permanent guideway structure. Even with the very optimistic assumption of $1 million per mile construction cost, the capital cost is extremely high. The expected arrangement would be a guideway system with an inherent directional capacity of over 30,000 persons per hour and a lifetime of several decades which would be overbuilt for the planned use of 1,700 persons each way per day over four years. Because Circle already has rail service, the line would not have significant long-term value as a new branch for freight service.

C. Airplane

Because initial comparisons indicated that air transportation would be the most cost effective, a more detailed analysis was accomplished.

The 120-mile distance of the trip indicates that a propeller aircraft should be used rather than a turbojet, and because of the large number of passengers to be carried, a large airplane is necessary. A survey of the current market revealed that only two four-engine propeller type airplanes are available in large quantities and are relatively free from problems of fuel and parts availability. These are the Lockheed Electra and the McDonnell-Douglas DC-6B. Basic specifications are as follows:

Type	Seats	Fuel	Operating Cost	Present Cost[1]
Electra	115	Turbine	$1400/hour	$1.0 to $1.5 M
DC-6B	90	100 octane Avgas	$ 700/hour	$0.25 to 0.35 M

Because the first cost and operating cost per seat favor the DC-6B, it is used in the remainder of the analysis. Major advantages of the Electra (greater cruising speed and altitude) are negated by the short trip length.

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[1] Cost varies with condition and spares included. The higher-cost Electras have cargo doors added and the price reflects the conversion cost.

In the capital cost requirements, which are summarized in Table E-1.7.2, it was assumed that all capital facilities (runway, hangar, etc.) would be available at Glasgow AFB. Operating cost calculations are shown in Table E-1.7.3. These conservative calculations show a range of $679 to $865 per hour, with the low end of the range more likely. Dealer quotes indicate a range of $600 to $700 per hour. For the purposes of this study, $700 will be used for balanced (minimum cost) shift schedules, and $800 will be used for unbalanced (maximum cost) shift schedules.

Because the trade-off between construction site and Glasgow AFB housing is not an either/or situation, costs for air transportation are calculated on a single plane load of 90 persons.

	Balanced Shift Schedules	Unbalanced Shift Schedules
Capital Cost, Airplane*	$ 300,000	$ 300,000
Capital Cost, Other*	2,400,000	2,400,000
Operating Cost Per Hour	700	800
Wage Cost Per Hour		
Straight Time: $12 + 20%	14.40	14.40
Double Time: $24 + 15%	27.60	27.60

Results of the capital cost estimates are summarized in Figure E-1.7.2. Only the extremes are included: double-time wage, unbalanced shifts at maximum and straight-time wage, and balanced shifts at minimum. The increment for balanced shifts to unbalanced shifts is $42,200 per year for each unit of 90 workers, a value smaller than the uncertainties in the estimates.

For reference, the no worker wage data are shown in Figure E-1.7.3.

E-1.7.4 Projected On-Site Housing Costs

Housing costs for construction workers on a proposed coal gasification project will be based on the costs incurred by the Montana Power Company (MPC) during construction of Colstrip Units #1 and #2. The maximum number of construction workers on the Colstrip project was 1,200. During most of the 4-year construction period, there were 700 to 800 construction workers on the project.

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* Capital costs are spread over three years to account for less than peak work forces in the first and fourth years.

Table E-1.7.2--Airplane Mode

Airplanes (Each)	$ 300,000
Plant-Site Airfield	
* 500-foot runway for DC-6B, with taxiways, apron, lights, including 25% engineering fees	$1,627,000
* Instrument Landing System	250,000
* Hangar, 125' X 140' X 35' clearance	350,000
Mobile Equipment	
* Snowplow/sander trucks (2)	100,000
* Fuel trucks (2)	30,000
* Ground power units & misc.	50,000
TOTAL EXCEPT AIRPLANES	$2,407,000

Table E-1.7.3--Operating Costs, DC-6B

			$ PER HOUR
FUEL:	Average 110 gal/hr/engine @ 85¢ per gallon		$ 374
OIL:	One (1) quart per engine per hour at $1.50		$ 6
CREW:	Assume 50% flight time, 50% ground time, and 86.6 flight-hours per month.		
	Pilot	$2300/mo	
	Co-Pilot	1500/mo	
	Engineer	1500/mo	
	(2) Cabin Attendants	1500/mo	
		$6800/mo	
	35% fringe benefits 86.6 flight-hours		$ 106[1]
MAINTENANCE:			
	Labor = 6 maintenance man-hours per flight hour Wage = $1400/mo + 35% fringe		$ 71
	Parts = 30% of new cost per year for 2000 hours per year		$ 45
INSURANCE:			
	10% of purchase value for 2000 hours/year		$ 15[1]
	Subtotal		$ 617
	10% Runway Maintenance, G&A		62
	TOTAL		$ 679

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[1] These will vary with use; for a single round trip per day, $265 per flight hour is maximum crew cost, decreasing by the value of crew members doing other duties (i.e., maintenance). Insurance may be as much as $25 per hour.

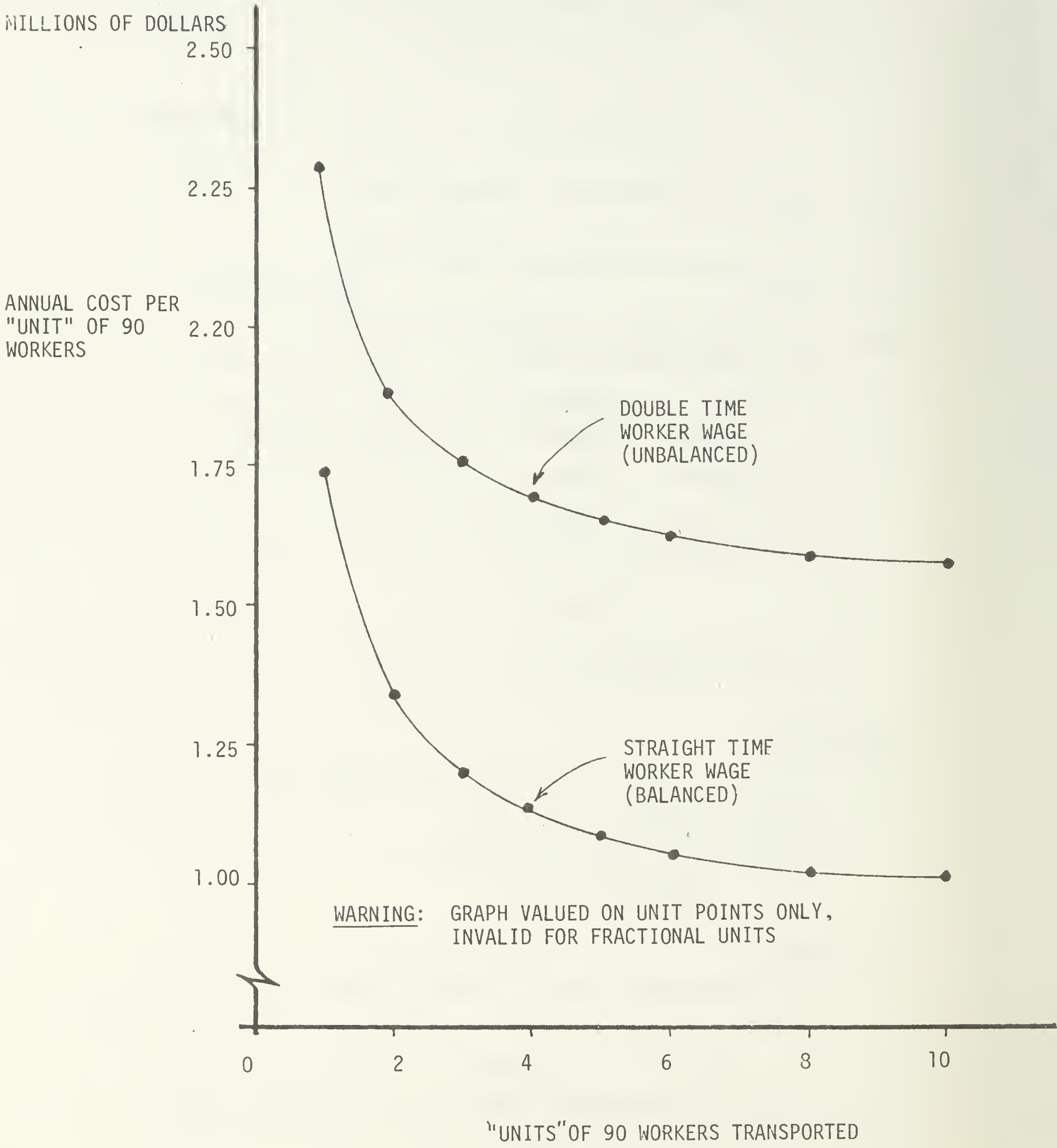

Figure E-1.7.2--Air Transportation Costs (Worker Wages)

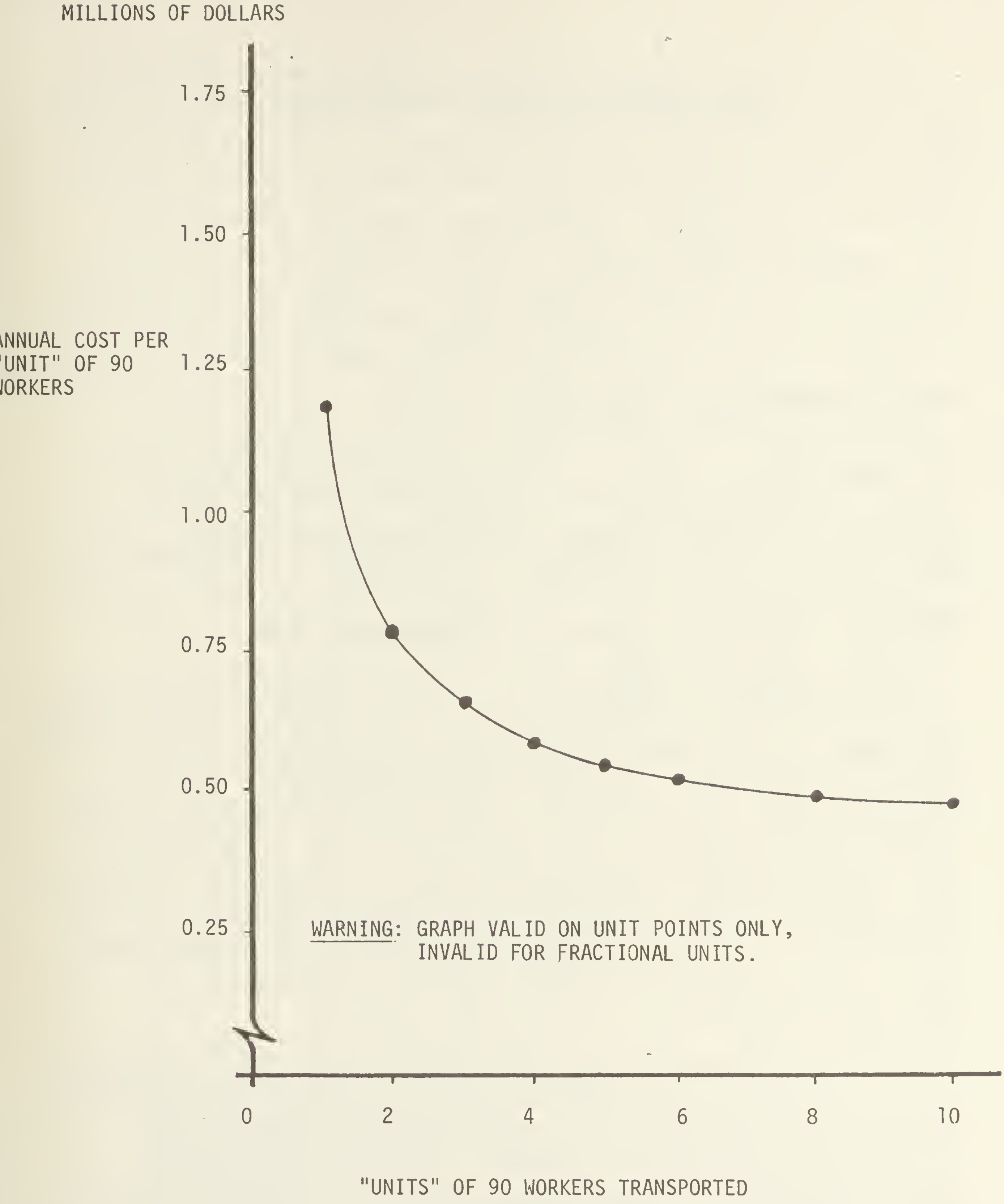

Figure E-1.7.3--Air Transportation Costs (No Worker Wage--Balanced)

Workers on the project found housing in a number of ways. Some commuted daily to and from their homes as far away as Billings (approximately 125 miles). Others found housing closer by, such as in Forsyth. In Colstrip itself, MPC provided housing in various ways, such as building 40 single-family houses at a total cost of $2.4 million. Western Energy Company, an MPC subsidiary, built a comparable number of houses. These housing facilities were built and operated by MPC and Western Energy Company. Although rents were charged to the tenants for use of the facilities, they were operated at a net loss to the company. MPC built a trailer court with 441 spaces at a net loss to the company of $986,000 (see Table E-1.7.4). Included in the cost of the trailer court is the cost of what MPC calls the "hobo camp," facilities for an unspecified number of campers. See Table E-1.7.5 for a breakdown of the trailer court and hobo camp costs. MPC also built a bachelor camp, see Table E-1.7.6. The bachelor camp provided room and board to workers at a cost of $10 per day which was deducted from their wages. The bachelor camp was designed for 230 people, but the one designed for this report was sized for 400 people. The initial bachelor camp costs are shown in Table E-1.7.7

It is projected that there will be a maximum of 2,300 construction workers for the coal gasification project and that there will be 600 permanent jobs following construction. Assuming that the 600 necessary permanent housing units will be built prior to the major phase of construction, it can be assumed that there will be a need for 1,700 temporary housing units because housing is not as plentiful in the Circle area as it was in the Colstrip area. During the peak of construction at Colstrip, approximately 850 construction workers were housed in company-provided temporary housing. Therefore, twice the facilities would accommodate the 1,700 Circle construction workers. Costs will be calculated on a bachelor camp filled to design capacity (see Table E-1.7.8).

Costs of sewerage will not significantly affect the cost of temporary housing. Assuming that the stabilized population in Circle will approximate that in Colstrip after Units #3 and #4 are built, the community would need a treatment facility to accommodate a population of about 4,000. Based on the costs of a package treatment plant for a Hill County community, Table E-1.7.4--Trailer Court Balance Sheet[a]

	Colstrip[b]	Multiplier[d]	Circle[c]
Purchase & Installation Costs	$1,226,000	1.77	$2,170,000
Operating & Maintenance Costs	360,000	1.77	637,000
TOTAL COST OF PROJECT	$1,586,000	1.77	$2,807,000
Income from Rents	- 600,000	1.77	-1,062,000
NET LOSS TO COMPANY	$ 986,000	1.77	$1,745,000

---

[a] Over length of project, 441 lots

[b] 1973 dollars

[c] 1979 dollars

[d] Inflation adjustment factor, 1973-1979 (10% per year)

Table E-1.7.5--Initial Trailer Court and Hobo Camps Costs[a]

	Colstrip[b]	Multiplier[d]	Circle[c]
Trailers	$ 154,000	1.77	$ 274,000
Clearing & Grading	244,000	1.77	432,000
Sewer Lines	342,000	1.77	605,000
Water Lines	315,000	1.77	558,000
Roads & Walkways	35,000	1.77	62,000
Trailer Pads	27,000	1.77	48,000
Electrical Lines	109,000	1.77	193,000
PURCHASE & INSTALLATION COSTS	$1,226,000		$2,170,000

---

[a] 441 lots

[b] 1973 dollars

[c] 1979 dollars

[d] Inflation adjustment factor, 1973-1979 (10% per year)

Table E-1.7.6--Circle Bachelor Camp Costs[a]

	Design Capacity[b,c]
Purchase & Installation Costs	$2,347,000
Operating & Maintenance Costs	3,442,000[d]
TOTAL COST OF PROJECT	$5,789,000
Income from Rents & Meals	- 1,770,000
NET LOSS TO COMPANY	$4,019,000

---

[a] 1979 Dollars, over a length of project.

[b] 400 workers in camp designed for 400.

[c] Costs & rents increase by 400:230 = 1.74.

[d] Of O&M costs, the meal costs would not increase with a camp designed for 400. In both cases, meals amount to $1,593,000. Other O&M costs amount to $1,062,000 and $1,849,000, respectively. Totals $2,655,000 and $3,442,000.

Table E-1.7.7--Initial Bachelor Camp Costs[a]

Item	Colstrip[b]	Multiplier[d]	Circle[c]
Mobile Units	$ 581,000	1.77	$ 1,028,000
Cleaning & Grading	17,000	1.77	29,000
Foundations	24,000	1.77	43,000
Erection	81,000	1.77	143,000
Sewer Lines	24,000	1.77	43,000
Water Lines	3,000	1.77	5,000
Roads & Walkways	7,000	1.77	12,000
Electric Lines	25,000	1.77	44,000
TOTAL	$ 762,000		$1,349,000

---

[a] Camp designed for 230 workers; camp includes 22 ten-man sleepers, 2 five-man sleepers, 7 toilet/shower/laundry units, 3 recreation units, 1 dining complex with 3312 sq. ft. of dining space, 1 kitchen, 1 bake shop, 1 dry storage/office, 1 walk-in refrigerator, 1 utility unit.

[b] 1973 dollars

[c] 1979 dollars

[d] Inflation adjustment factor, 1973-1979 (10% per year)

a package plant for Circle could be expected to cost $1.1 to $1.4 million (1979 dollars) including right-of-way. Enough of those costs are fixed so that the cost of a package plant sized to accommodate a community during peak construction of twice the stabilized population would be in the $1.5 million range, a small increase in cost. Depending on land costs in the Circle area, a lagoon might be less expensive than the package plant. Sewerage costs to accommodate temporary workers would be about $150 per worker (250,000 ÷ 1700) or about $13,000 per 90-worker block.

Additional costs for temporary educational facilities would be in the same range. In Colstrip, MPC spent $170,000 (1973 dollars) to provide temporary structures for 8 classrooms and office space. Assuming again that the Circle impact would be twice the size of the Colstrip impact, the cost for temporary educational facilities (with inflation) would be about $600,000 (1979 dollars). Since this impact would not be derived from workers in the bachelor quarters, we omitted them from consideration. Temporary educational facility costs would be about $680 per worker housed in family quarters (600,000 ÷ 882) or $61,000 per 90-worker block. With these figures, we can estimate costs per 90-worker block (one plane load) for each type of housing arrangement (see Table E-1.7.8).

Part of the costs of one other housing alternative can be generated from these figures. Note that Table E-1.7.5 shows trailers purchased for the trailer court. Twenty-one trailers were purchased by MPC and rented to workers. However, available MPC figures do not itemize the operation and maintenance (O&M) costs for those trailers or the rent collected. Those amounts are part of the overall O&M and rent figures shown in Table E-1.7.3. Therefore, the previous 90-worker costs and net loss include purchase, O&M, and rental for 4.9 trailers per 90-block. If the company at Circle were to purchase and rent railers for the entire trailer court, purchase cost per 90-worker block would increase by $1,174,000. O&M and rent over the length of the project are unknown for these additional trailers.

Table E-1.7.8--Project Costs Per 90-Worker Block

	Amount
* Trailer Court (4.9 trailers per 90-worker block)	
Project Costs[a]	$ 573,000
Sewerage Costs	13,000
School Costs	61,000
Total Cost per 90-Worker Block	$ 647,000
* Design Capacity Bachelor Camp	
Project Costs[b]	$1,303,000
Sewerage Costs	13,000
Total Cost per 90-Worker Block	$1,316,000

---

[a] $2,807,000 ÷ 441 x 90 = $573,000

[b] $5,789,000 ÷ 400 x 90 = $1,303,000

E-1.7.5 Housing on Site Versus Glasgow AFB Housing

In the previous discussion, costs of transporting construction workers by air from a remote site to GAFB and the costs of building temporary housing at the construction site have been evaluated for a hypothetical case. The relative costs of each will now be compared. The reader must keep in mind that these discussions are estimates for a specific mine site located about 120 miles from Glasgow AFB. Depending on the eventual coal mine site location and other factors, such as changing construction costs, transportation capital costs, fuel costs and availability, to environmental and social constraints, the calculated relative costs for both the transportation and temporary construction camp could change.

From figures E-1.7.2 and E-1.7.3 one can see that the air transport costs decrease for increased units of workers transported. For discussion purposes here a minimum of five units will be considered. This results in the following resultant annual per unit transportation costs:

Double time wage	$1,640,000
Straight time wage	1,100,000
No wage	500,000

Next, costs associated with construction of temporary housing (similar to that provided at Colstrip #1 and #2) at the mine site will be listed. These values can be compared against the transportation costs listed above, to see if there is any economic advantage to housing workers at Glasgow AFB rather than the construction site. To simplify the comparisons, only construction costs associated with providing the temporary facility (both housing and support) construction site will be used for comparison to Glasgow AFB transportation costs. It will be assumed that operation and maintenance costs and income from rent for each housing type will be the same at the construction site or Glasgow AFB. These costs for a trailer court with a limited number of trailers (as was the case at Colstrip), a trailer court with a trailer for each worker and a bachelor camp are provided in Table E-1.7.9.

Comparing the annual costs for each option shown in this table with the transportation costs listed previously show that there is no economic advantage to the proposed commuter community scheme proposed.

Table E-1.7.9--Project Cost Comparisons per 90-Worker Block

	Construction	Sewerage	Schools	Total	Total per Year
Trailer Court (4.9 Trailers per 90-Worker Unit)	\$444,000[a]	\$13,000	\$61,000	\$518,000	\$173,000
Trailer Court[b] (90 Trailers per 90-Worker Unit)	\$1,213,000[c]	\$13,000	\$61,000	\$1,287,000	\$429,000
Bachelor Camp Costs	\$528,000[d]	\$13,000	---	\$541,000	\$180,000

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[a] \$2,170,000 ÷ 441 x 90 = \$444,000

[b] Salvage value for trailers of 1/3 purchase price (1979 dollars)

[c] \$(2,120,000 ÷ 441 x 90) + \$(1,174,000 ÷ 3 x 2) = \$1,287,000

[d] \$2,347,000 ÷ 400 x 90 = \$528,000

One option not considered in Table E-1.7.9 is that of substituting on-Base family housing for on-site bachelor camps. Such an arrangement would substantially improve family circumstances. This option was costed by considering full operational costs of the bachelor camps (see Tables E-1.7.6 and E-1.7.9) as opposed to the transportation costs for no wage compensation for travel to the worker. The calculated costs for the bachelor camp are $439,000 per year per 90-worker unit, while the transportation costs are $560,000 per year per 90-worker unit.

E-1.8--THE INTEGRATED PRODUCTION OF ETHANOL, BIO-GAS, AND LIVESTOCK AT GLASGOW AIR FORCE BASE

E-1.8.1 Introduction

The text focuses upon the economic potential and projected environmental impacts arising from an ethanol/gasohol pilot plant designed by the ACR Company, New Jersey. However, the original intent was to incorporate the fermentation process into an essentially closed system, termed an Integrated Agricultural Facility. Unfortunately, the adverse results of the preliminary economic analysis of the concept forced it from serious consideration. It is included for future consideration in case it can be redesigned in a manner to allow the overall process to be economically competitive with the more conventional process techniques.

In order to meet the objective of economical ethanol and by-product production at Glasgow Air Force Base (GAFB), an integrated agricultural processing facility (IAF) which can be scaled to meet the needs of regional farm operations is proposed. This facility may approach energy self-sufficiency and will attempt to recycle as many materials and by-products as realistically feasible. The major components of this feedback system are

1) An enclosed livestock feedlot,
2) A meat processing facility,
3) An ethanol/gasohol plant,
4) A series of bio-gas generators, and
5) A high-protein algae-culture pond.

The entire cycle initiates with inputs of wheat (or barley or possibly other local agricultural products), alfalfa, cattle feed, water, heat (boiler process steam and solar), and bentonite. Manure, low-Btu synthetic natural gas (SNG), electricity, distillers dried grains and solids (DDGS), offal, fusel oil, CO_2, and other minor by-products are produced during the cycle. The major outputs are industrial grade ethanol (95% v/v), gasohol blend, beef, hides, biomass, and high-nitrogen fertilizer.

Energy and materials are cycled through the component structure. Manure excreted by cattle is anaerobically digested to produce SNG (approximately 65% v/v methane) which is utilized to generate the electricity consumed in the processing of both the manure-sludge and the diluted milled grains used in ethanol production. High-Btu steam possibly produced by "flashing off" hot water feed from the existing high-temperature hot water (450^{o}F, 275 psi) underground insulated steel pipe distribution system may be used to distill and process the pre-ethanol, water-diluted and milled grain mixture. The anhydrous ethanol produced after processing is blended with unleaded gasoline to yield high octane gasohol. Distiller's dried grains and solids are separated from the fermentation solution and either can be marketed or cycled to the feedlot for use as a food supplement. The feedlot cattle will be slaughtered after a 120-day process period, and the carcasses and hides may be marketed locally. Offal and other organic by-products can be cycled to the bio-gas digesters. Distilled "thin stillage" (processed fermentor supernatent) will be used to grow high-protein algae in small solar-heated ponds. The harvested single-cell protein (biomass) can serve as further food supplement for the cattle.

E-1.8.2 Feedlot

An enclosed feedlot for GAFB would grow grain-fed "fat" cattle, utilizing local grain crops (e.g., wheat and barley). A projected figure of 1,000 cattle per year, or 330 steers and heifers per 120-day process period, will require the types and volumes of rations included in Table E-1.8.1.

The feed will be pelletized, and the alfalfa will be dried (on-farm), mill-shredded to 30.5 lbs. per cubic foot, and baled.

Based on space calculations for Building #666 (74,336 feet^2; L = 368 feet; W = 202 feet; and H = 22 feet)--a former Safeguard Service and Maintenance Facility--the cattle pen area (approximately 120' x 150', which will accommodate 333 head per time); grain and alfalfa storage (12' x 150', including 25 days supply of ethanol plant feed stock); and meat processing facilities (75' x 200') can be situated in the same building. Building #666 is located near a Burlington Northern railroad spur, which will facilitate the transfer of cattle and grain to pens and storage.

A. Cattle Transfer and Maintenance

The conceptual design of the cattle pens is based on a total systems approach which will mitigate potential air and water pollution problems by retaining all unconsumed and unprocessed foodstuffs, manure, and process water within the feedlot or on space adjacent to the operation. The wastes generated by the feedlot will be recycled through the production of electrical energy by anaerobic digestion and bio-gas synthesis and through the growth of (digester) slurry-fertilized feed crops which can be ultimately be used to feed the cattle. The design also will

Table E-1.8.1--RATION SCHEDULE, WEIGHT GAIN, AND RATION VOLUMES

(Average Annual Basis)

	Tons	Pounds/Foot^3	Total Density[a]
Feed	693.4	50.0	21,305.7 lbs/ft^3
Alfalfa	138.8	30.5	9,101.6 lbs/ft^3
Barley	554.6	38.6	28,735.7 lbs/ft^3

	Steers	Heifers[b]	Ration Type
Pounds (initial)	750	450	(Initial) Alfalfa
Pounds (finish)	1125	920	(Growing) Concentrate and Alfalfa
Weight gain	375 lbs.	470 lbs.	
Time period	160.2 days	200.8 days	(Finish) High protein concentrate and supplements.

a) Source: Montana International Trade Commission

b) Source: Four Corners Commission (Colorado Bio-gas, Inc.)

allow maximum weight gains per process period while minimizing aesthetic (visual) and noise impacts and ideally eliminate insect and/or rodent infestations. Feed is fed (via slurry) to the cattle bunks (pens), and the consecutive output of processed manure is channeled to the bio-gas plant.

The process is initiated with the transfer of calves (approximately 400 lbs/calf) from rail cars (45 calves to a deck; two decks per car) to a 14' x 5' chute. The chute leads to a branding chamber where the cattle are branded, weighed, and sprayed with a low-toxicity solution. The processed calves enter a passage (approximately 10' wide) that leads to the pens.

The cattle pens are designed to facilitate both the feeding of the cows and the sanitary removel of wastes. Each pen would require the removal of concrete to allow a one percent maximum slope into an in-pen drainage slot. The slot periodically would be flushed with water (about 60 minutes per day) into the central collection channel that has been excavated to allow a four percent drainage slope into the primary settling basins. Assuming 11 rows of pens with 30 pens per 92.5-foot row and a one foot wide drainage channel per row (0 feet deep at the top of the ditch, and grading to 3.6 feet deep at the bottom), then about 4.7 gallons per minute (for a total 60 minutes/day flush) should be adequate for each drainage ditch in order to dilute the 25,608 lbs. per day of cattle manure to a 1:1 water/manure slurry. Each pen will be about 15' x 5' (including feed and water bunkers).

B. Meat Processing

A meat processing facility presently is in operation near GAFB. This facility, operated by the Glasgow Packing Company, is unable to process grain-fed, "fat" cattle because of carcass storage and refrigeration problems. This means, depending upon market conditions and transportation costs, that prospective GAFB cattle must either be shipped directly to another processing facility (e.g., Billings, Montana) or processed on-site. The following discussion is based on the second option.

Based on information provided by a grain-fed cattle slaughtering operation known as the Richland Packing Company in Butte, Montana, a meat processing facility with a capacity of 80 head per week requires six to seven personnel. To accommodate 80 carcasses per week, approximately 1,125 feet^2 of refrigeration floor space is required. Assuming an enclosed refrigeration unit 75' x 15' x 8' located near the south entrance of Building 666 (with a vestibule near the carcass loading area), the approximate total load necessary to maintain 10,592 lbs/day of meat at 30°F is 26,048.34 Btu or 7.63 Kw/day. The frozen carcasses can be shipped weekly by truck or rail (depending upon transportation costs).

Sixteen cattle per day or two cows per hour (@ 1200 pounds live weight) can be processed with two power saws, a boner (a rotating brush-like device that removes excess meat from the bones), and a high caliber pistol. The cattle are removed from their pens and placed in a holding pen adjacent to the killing decks. Two cattle are placed on platforms which drain into 4' x 4' x 4' offal storage tank (to accommodate the blood-letting) and shot in the head. Their hind legs are bound with chains and hoisted into the air using a movable crane. They are butchered and boned using the power equipment. The carcasses are transferred (via overhead crane) to meat hooks located inside the refrigeration unit. The offal and by-products (7,060.5 lbs/day) are scrapped off the killing decks into the adjacent holding tank where it is processed and transported to manure (predigestion) collection tanks (described in detail below). The hides are transferred to storage, stacked, and marketed.

C. Grain Transfer, Unloading and Storage

The grain is brought into the facility via bottom-dumping grain cars or by truck and fed into the storage system.

The vehicle-to-storage process involves the gravity loading of locally purchased dry grain into the grain pit, and the transfer up and into the hopper. This hopper will be supported by a steel frame and be of sufficient height that a swing pipe orginating from the tank bottom can be positioned over a particular bin. A gate-type release will be actuated, with the material then flowing through the pipe and into the given bin. It may be necessary to occasionally move the loaded grain away from the deposit area within the given tank in order to achieve an even filling distribution. The ventilation fans (ceiling-mounted) must be operated during the grain transfer/bin-loading process in order to avoid the buildup of potentially explosive dust concentrations in the air.

Assuming that storage volume capacity is sufficient to meet a 25-day demand period for both the feedlot/bio-gas and ethanol plant operations, the following approximate bin specifications and transfer schedulings have been estimated (Table E-1.8.2).

In addition to grain storage, consideration must be given to the 10.5 tons (690 feet^3) of alfalfa hay for feedlot operations and the 107.5 tons (8920 feet^3) of baled wheat straw for bio-gas operations during each 25 day period. These materials can be stocked in an area 50' x 20' x 10' (high). Assuming that the demensions of a bale are about 2' x 2' x 4', then such a pile would hold up to 625 bales; this represents about four percent excess volume. These bales could be transported from the delivery vehicle to storage via a chain-driven hay elevator.

A large (65' x 130' x 5') bin will have sufficient volume to store the required amount of barley or wheat, allowing for two percent by volume for grain expansion, non-uniform packing, and so forth. Small (45' x 30' x 3') bins should be more than adequate to handle the feedlot barley, pelletized feed, and DDGS solids/slurry.

The grain from the large bin will periodically be removed via sliding gates, then passed down a small chute and on to the belt conveyor or moved into the ethanol plant for milling (i.e., prior to entry into the precooler vessels described below). Materials in the small bins will be withdrawn in a similar manner but using a second conveyor; these materials (e.g., feed rations and barley) pass into the collection hopper and then are ground and mixed together as they fall from the hopper through the knives into the finish hopper. The process ration could then be moved by 1/2 ton pickup into the feedlot area where it is shoveled into the feed bunks. If bentonite is to be included in the ration as a means of accelerating weight gain, it would be stored in a portion of a "small" bin and blended with the other formula items at the time of ration preparation.

TABLE E-1.8.2--GRAIN AND OTHER MATERIAL(S) STORAGE SPECIFICATIONS
(25 Day Operating Period)[a]

IAF Component	Material	Weight (Tons)	Volume (ft^3)	Possible Bin Dimensions (ft)[b]
Feedlot	Pelletized	52.5	1615.	30x43x2
	Barley	42.0	2177.	30x43x3
Ethanol	Wheat	750.0	31.120	65x130x5[c]
	Barley	800.0	41.451	65x130x5[c]

a) Assumes a 365 day production year for the feedlot and no less than 312 days per year for maintenance of the ethanol plant and bio-gas operations.

b) Assumes a total (maximum) area of about 12,350 ft^2 if all associated machinery, etc., is included in the space estimate.

c) Only one grain will probably be fermented at a given time.

E-1.8.3 Ethanol Plant

The ethanol facility envisioned for GAFB will utilize conventional physio-chemical and biochemical processes to convert amylaceous or sacchariferous raw materials (from local suppliers) into anhydrous ethanol and marketable by-products. A conceptual scheme, presented by process phase, will be reviewed in the following sections. Please note that conventional, i.e., non-ACR technology, is presented in this section to give the reader an understanding of the "more usual" way of preparing industrial grade ethanol.

A. Pretreatment Phase

Locally grown grain crops will be transported to the GAFB site by existing roadways or rail and stored in Building #666. It should be noted that grains of lower quality, i.e., "out of condition" feedstocks having moldy or excessive moisture characteristics,can be incorporated easily into the fermentation process. Building #667 has space available for the cookers, mixers, and stills necessary to process the grains and to distill the ethanol.

Prior to decomposition, the whole grain is withdrawn from storage, continuously weighed and cleaned to remove adhering contaminants, and ground to approximately 10 mesh via roller mills. This milling exposes the interior (amylaceous) portion of the grain. Feedstock size reduction is important only in assuring effective pumping, agitation, etc. without disruption of process continuity due to malfunctioning equipment. The milled grain is gravity fed into a precooler vessel, mixed with warm water (120°F) and malt (the pH adjusted to 5.3 to 5.5), and mechanically agitated with impellers for about one minute. The warmed mixture is then pumped to a steam jet-heated continuous cooker. The mixture is heated to about 360°F in the U tube-shaped system using steam produced by the existing utilities plant located about 0.5 mile east-southeast of the proposed ethanol facility. The gelatinized starch slurry is cooled almost instantly to the saccharification temperature (145°F) first by entering tangentially into an expansion tank operating at 240°F and subsequently by entering into a 145°F vessel. In order to preserve heat economy, the flash steam from the 240°F tank is recovered and directed to areas using process heat. Cooling to the conversion temperature is accomplished by using either a water-cooled shell or tube heat exchangers within the tank. Small amounts of alpha-amylase are added before and during cooling to reduce viscosity and initiate dextrinization of the process slurry (i.e., the ruptured starch granules from the saccharification vessel).

B. Hydrolysis Phase

The partially-cooled slurry is pumped to hydrolyzer tanks where it is mixed with hydrolytic emzymes (probably beta-amylase and alpha-glucosidase; the former hydrolyzes the 1→4 oxygen linkages in starch and dextrins, while the latter attacks the 1→6 oxygen linkages of the limit dextrins). The enzyme(s) could either by created by propogation of bacterial or fungal microbes with the extraction of hydrolyzate from the nutrient medium or purchased from a commercial source. The conditions under which enzymatic cleavage occurs must be carefully controlled (i.e., with regard to temperature, pH, and reaction time) to assure about 80 percent saccharification efficiencies. After appropriate resident time, the five to fifteen percent v/v sugar solution is pumped, in plug-flow manner, to the fermentation vessels.

C. Fermentation Phase

Having charged the fermenters with sugar solution (adjusted to five to ten percent v/v dissolved solids concentration) and added Saccharomyces cerevisiae yeast culture and nutrient media, the mash is heated to 92°F, pH 4.5 to 5.7 and fermented for 24 to 36 hours. During this time about 95 percent of the original amylaceous feedstock is converted to alcohol and associated by-products. The CO_2 generated during the fermentation is stripped of any entrained ethanol; the gas is then further directed for processing (e.g., compression) or disposal. It is envisioned that a continuous fermentation design allowing simultaneous growth and fermentation processes will be implemented in this phase.

D. Distillation Phase

Regardless of the fermentation flow (i.e., batch or plug-flow) design ultimately applied, the distillation process will be continuous. The preheated (160°F) beer feed, containing up to twelve percent v/v alcohol, is pumped to the primary (beer) still where essentially all of the alcohol is distilled overhead via steam heat (217°F; 1.5 psi) at a concentration of about 50 percent (liquid) volume. The remaining water, containing both dissolved and undissolved solids, is drawn from the bottom of the still and fed (possibly) into a centrifuge. The liquid phase can be then concentrated to about 50 percent (w/v) dissolved solids in a multi-stage evaporator and mixed with solids from the centrifuge. The thick fraction or paste can either be pumped to the feed lot or solar dried to ten to fifteen percent (w/w) moisture content, pelletized and bagged or bulk-stored for regional ruminant feedstock. This material, termed distiller-dried grains (DDG) is composed of unfermented starch, fiber, ash, and 28 to 36 percent protein (w/w), thus serving as a source of high nutrition animal feed.

The alcohol vapors from the beer column pass into the second concentrating column operating at about 154°F, 0.8 atmospheric pressure. Water is discharged from the base for use in waste recycling while approximately 96 percent (v/v) ethanol is withdrawn from a plate near the top of the column. The upper-most portion of the column is utilized for the concentration of low-boiling impurities such as aliphatic alcohols, aldehydes, ketones, fusel oil, etc. These extracted substances can be pumped to on-site storage facilities and later sold as marketable by-products (e.g., as feeder stock for fuels, solvents).

The purified 95 to 99 percent alcohol is then fed into the tertiary dehydration column. The ethanol/water azeotrope (bp of 78.15°C) is broken by the addition of a carrier substance (e.g., benzene, heptane, or diethyl ether) where the temperature/pressure parameters are adjusted to the particular carrier requirements. This column thus produces anhydrous ethanol, about 99.98 percent (v/v) in purity. The product could be pumped to the existing but retrofitted jet fuel storage system (storage capacity approximately 3.5 million gallons, accommodating up to 3.8 years of product). In addition, off-loading facilities exist adjacent to both the rail-spur and truck depot area. Given the existing physical facilities, transfer of the ethanol and by-products would not present unwieldly logistic problems.

The carrier, together with the entrained water, passes overhead to a steam reboiler. This process both recycles the carrier and provides low-pressure/low enthalpy steam elsewhere in the plant. The feed to the dehydrating column is controlled to balance the output from the rectification column's production of 95 percent ethanol. The water layer from the dehydration column is withdrawn at a rate corresponding to the water volume present in the alcohol output from the secondary still. It should be noted that the overall distillation design/ operation has been taken from Theodore O. Wentworth, et al. at the USDA Northern Regional Research Laboratory in Peoria, Illinois.

E. Materials Summary

For a projected output of 2,500 gallons anhydrous ethanol per day, about 30 tons of wheat per day or 32 tons of barley per day must be processed through the ethanol plant. At an average 30 tons per day input over a 350 day operating year, local grain could supply the bulk of the biomass required to maintain projected ethanol output.

Approximately 142,000 gallons per day of cooling and total process water is required by the ethanol facility. The primary water supply delivery system to GAFB initiates from the Fort Peck Reservoir. There are four pump stations, each having one 645 gallon per minute (gpm) pump, one 400 gpm pump, and two 1405 gpm pumps. The water flows through an 18" concrete pipe. A secondary back-up supply consisting of two shallow wells each having a 250 gpm pump directs flows into an 8" water line. The secondary system is only used during the complete failure of the primary supply. On-site storage consists of three elevated steel tanks with capacities of 400,000, 400,000, and 300,000 gallons. Base distribution is through cement asbestos pipe (18" diameter). Service lines are copper. A water treatment facility has a capacity of 3,009,600 gallons per day with historical use rates nearer to 2,600,000 gallons per day.

Other materials involved in the production of ethanol are Saccharomyces cerevisiae yeast culture and nutrient media (approximately 500 lbs. per day) detergents, antifoaming agents, and sterilants (e.g., formalin) --ten pounds per day--and approximately ten gallons of make-up carrier per day.

In addition to 2,500 gallons of anhydrous ethanol per day and about 9.5 tons (wet weight) DDGS per day, there will be about 8.25 tons of carbon dioxide (CO_2) and 210 lbs. of by-products including fusel oil produced during processing. If the fusel oil is not marketable, it would be disposed of through incineration or mixed with the boiler fuel oil (if this steam generation option is exercised).

During DDGS processing, odors and possibly particulate emissions will be produced. These can be controlled by filter/scrubbing devices, as necessary.

The electric power for base operations is purchased from the Montana Power Company (MPC); there is an on-site company-owned substation having a 10,000 Kva transformer capacity. The electric system is primarily overhead, with some minor underground runs; the supply voltage is 69,000 volts with a primary distribution of 7,200/12,470 volts. There are 51 diesel generators, ranging from 2.5 Kw to 300 Kw in generating capacity, to supply standby service. The estimated average power load required by the ethanol plant is about 225 Kwh/h. This could be met through bio-gas generated electricity (assuming adequate manure supply) although present GAFB capacities will provide back-up electricity in any case.

E-1.8.4 Feedlot Bio-Gas Plant Integration

The waste materials generated from the cattle will be flushed down four percent sloping collection channels to a series of collection basins. The calculation of required storage columns is based on the assumptions included in Table E-1.8.3.

Using the information from Table E-1.8.3, projected system input can be calculated. The results are given in Table E-1.8.4.

It is envisioned that the manure/urine slurry will first pass through a 2" mesh steel screen (one per slotted drain channel) and then through a gravel filter bed. The liquid will exit through a 1" mesh steel screen and into a series of collection basins interconnected by 2" diameter PVC-type cold water supply pipe. It is proposed that three tanks (151 ft^3, 498 ft^3, and 664 ft^3) be excavated from portions of the existing concrete pad (Building #666) and lined with bentonite and Hypalon®-type inert rubber sheeting. These tanks will allow sand, grit, and other particulate matter to settle (for periodic removal) prior to siphoning the slurry supernatent from the smallest to largest storage tank. This fluid transfer process

TABLE E-1.8.3--MANURE INPUT ASSUMPTIONS

1) Beefcattle (@ 1200 lbs.) will produce 92.3 lbs. (1.60 ft^3) of wet weight manure per day. This is composed of 7.98% w/w volatile solids, 0.27% nitrogen and 0.10% phosphorous.(a)

2) Mature wheat straw is composed of 21.6% w/w lignins and 26.4% w/w hemi-celluloses in air-dried material (15% for fresh-weight material).(b)

3) The carbon to nitrogen ratio input must average 30:1. 75% of the straw's total nitrogen is digestible within 25 days (assuming 7.2% solids).

a) National Academy of Science, Table II-6, p. 41.

b) National Academy of Science, Table II-4, p. 38.

TABLE E-1.8.4--PROJECTED SYSTEM INPUT FROM THE ENCLOSED CATTLE FEEDLOT OPERATION PER DAY

	Pounds	Tons	Cubic Feet
Urine/Manure	30,730	15.4	532
Water (for slurry)	30,730	15.4	493
Milled Wheat Straw	10,243[a]	5.2	425[b]
			1450[c]
			1313 Provided

a) Ball-milled material, possibly 10 mesh.

b) Assume 24.1 lbs/ft^3 density.

c) Note that the nearly continuous feed to the digesters should allow a holding capacity that is somewhat less (10%) than manure production volume.

may require a sewage lift pump with float switch activation. The rough milled straw will be added while mechanically agitating the fluid to assure proper material homogeneity prior to input into the digesters. The manure/straw slurry will then pass from Building #666 into the A&E shop portion of Building #667 via passage through the personnel/transport tunnel.

A. Collection and Pumping of Raw Slurry

The excreta (manure and urine) will be washed down the slotted pen gutters into centralized series of gravel filter beds via low pressure hoses approximately every eight hours. The manure/water slurry will be siphoned into the mixing tank (primary settling tank No. 3) aided by suction created by the submerged pump or sewage lift pump located in the third tank.

The rate of flow into the settling tanks, in conjunction with the gravel bed and screen filters, will be adjusted to allow a grit-free manure/water slurry to enter into the specially designed mixing tank.

The slurry enters the mixing tank (No. 3) in a manner that causes a tangential flow along the tank sides, consequently producing a circular movement/mixing of the raw material input. Potential pump clogging (despite screening the input orfice) during the simultaneous addition, mixing and pumping of manure/water slurry with the milled straw may occur if not properly managed. Thus, mechanical agitation will be utilized to maintain a dissolved/suspended solids concentration of no more than 8.5%. The operator should monitor the input by collecting periodic samples and then sending them to the nearby (proposed) IAF laboratory in order to check appropriate C/N ratios, solids loading, and other important engineering operational parameters (to be identified during the detailed design study period).

The slurry is pumped out of this third tank and passed through 2 inch medium to 4 inch maximum (inside) diameter) PVC-type, insulated pipe from the feedlot operation to the bio-gas plant.

B. Bio-Gasification

A close examination of energy use by farm animals suggests that, depending on the species, the excreta (dung and urine) may contain from 12 to 23 percent of the energy initially consumed by the animal (D. D. Schulte, et al. 1976). The remaining energy is apportioned to activity, body maintenance, respiration (heat loss) and meat, milk or egg production. To fully optimize energy and materials cycling (developed in the ethanol plant and feedlot discussions), it is proposed that a bio-gasification plant and an algae pond be utilized to effectively integrate the various components of this re-use alternative. Energy recovery from the manure via thermochemical pyrolytic processes might substitute for the biological approach, although pyrolytic gas generation appears to possess more operating problems (e.g., slagging in the reactor and by-product handling and disposal) than bio-gasification (Lewis and Ablow, 1976). The manure-gasification process will serve two important functions: 1) to mitigate a potential solid waste disposal problem via manure conversion to a humus and nitrogen rich, non-pathogenic fertilizer (for later field application), and 2) to produce a methane-rich, medium-energy (600-650 Btu/scf) synthetic gas for plant mechanical electrical energy requirements. This would create a nearly energy self-sufficient operation. Ideally, bio-gasification will increase the efficiency of solar energy conversion to edible chemical energy (i.e., biomass), with a reduced need for fossil fuel supplementation.

Bio-gasification is similar to garden composting but requires different environmental conditions and results in different end products. Composting involves aerobic (oxygen-requiring) fermentation, producing large quantities of non-combustible carbon dioxide (CO_2) and volatile ammonia (NH_3) gases in addition to large amounts of sensible heat. Bio-gasification requires the absence of oxygen (i.e., anaerobic conditions), produces small amounts of CO_2 and heat, but yields great quantities (up to 65% by volume) of methane (CH_4) gas. This is the same combustible material found in refined natural gas. Because the process is tightly sealed, there are no nitrogen losses from the seepage of soluble ammonium (NH_4+) ions or the evaporation of NH_3 gas. The processed sludge contains from 50 percent to 75 percent (by weight) humus and is a superior nutrient and soil conditioner when compared with aerobically digested compost (Ram Bux Signh, 1971).

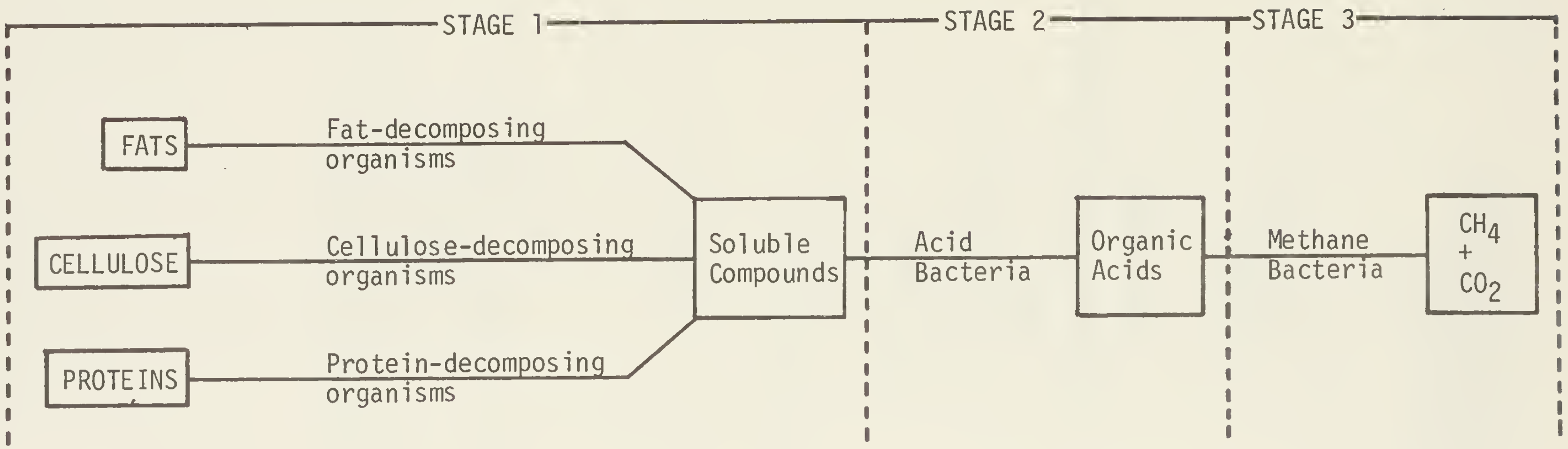
Anaerobic decomposition is a biological process commonly found in natural ecosystems such as marshes and in bottom debris of lakes and rivers. It also occurs in cattle rumen and as "fire damp" in coal mines. Much of the current understanding of how methane is produced via anaerobic fermentation is derived from its application in sewage treatment facilities to produce clean water. Although the values for crucial operating parameters significantly vary between commercial sewage plants and bio-gasification facilities, both processes involve the three-stage biological process shown in Figure E-1.8.3.

Initially (stage 1) aerobic bacteria convert biopolymers into simple soluble substrates (monomers) via enzymatic hydrolysis. These substances (stage 2) become the food for the acid-former bacteria which then convert them into low molecular weight organic acids which are primarily volatile butyric, propionic, and acetic acids. The third stage involves the anerobic fermentation of the volatile acids to methane and CO_2. The CO_2 is reduced to methane using either hydrogen gas (also present in solution) or formic acid (formate ions) produced by the "second stage" bacteria. The "bottle-neck," or rate-limiting step in this process is a four to ten day regeneration period for the various taxa of anerobic methanogenic (methane-producing) bacteria (National Academy of Sciences, 1977). Digestion effectiveness consequently depends upon the provision of optimum physiochemical conditions for methane-former (bacteria) support. Table E.1.8.5 presents important factors which must be carefully controlled for successful bio-gasification.

C. Nutrient Levels

One of the most important parameters in bio-gas production is maintaining the correct carbon to nitrogen (C:N) ration. The other factors listed above influence, or are influenced by, this parameter. The initial organic matter input (e.g., protein, fats, carbohydrates) will be digested as food for the "stage one" microbial flora. The primary nutrients are carbon, nitrogen, and phosphorous, which occur in an optimal ration of 100:3:0.6, respectively. Phosphorous is not a limiting (or controlling) factor, but the ratio of digestable carbon to nitrogen in livestock manure can be deficient, as shown in Table E-1.8.6.

Because the manure C:N ratio is low (i.e., insufficient carbon will result in incomplete nitrogen digestion), materials having a



Source: National Academy of Sciences, Methane Generation from Human, Animal, and Agricultural Wastes, Washington, D.C., p. 28, 1977.

Figure E-1.8.3----Anaerobic Fermentation of Organic Solids

TABLE E-1.8.5--CRITICAL PHYSICAL AND CHEMICAL FACTORS INVOLVED IN THE BIOGAS PROCESS

Physical	Chemical
Temperature	Alakalinity
Oxygen-free Environment	Volatile Acid Concentrations
Solids Retention Time	pH
Solids Leaching Rate	Toxic Materials
Solids Concentration	
Degree of Mixing	

TABLE E-1.8.6--APPROXIMATE MANURE COMPOSITION AND C:N RATIO VALUE

Component	Percent Composition (Dry Weight Basis)[a]
Ash	36.44
Volatile Solids	63.60
Protein	16.60
Fat Lipids	1.40
Carbohydrate	45.60
Fiber	16.30
Nitrogen-Free Extract	29.20
C:N Ratio	18:1[b]

a) Taken from Table 4-7 in Burford and Varani; composition will vary with feed formula.

b) Taken from Table 5 in Methane Digesters for Fuel Gas and Fertilizer, New Alchemy Institute Newsletter No. 3, 1973.

high C:N ratio should be mixed with the animal wastes to restore a proper nutrient balance. Small amounts of wheat straw, with a C:N ratio of 150:1, are an ideal digester input.

D. Gas Production

Assuming that the operating parameters listed in Table E-1.8.5 have been set at optimal values, the acid-former bacteria will rapidly hydrolyze the complex macromolecules to volatile organic acids, thus lowering the pH to about 6 and also releasing large quantities of poor quality gas rich in CO_2. This is followed by an equilibrium phase of methane production which restores the pH to at least 7.5; the now buffered solution yields less CO_2 and more CH_4 than initially.

The methane:carbon dioxide ratio generally is about 1.9:1 (by volume) in manure digesters with an average energy production of 600 Btu/scf of gas.

Although gas production (per unit animal) will be determined by the formula of the feed ration and feed rate, theoretical yields of 8.75 ft^3 CH_4 per lb. of carbohydrate-derived volatile solids (vs) carbohydrate material have been calculated by Burford and Varani. However, their Colorado pilot plant studies reveal an average expected conversion efficiency of 54 percent. If this is correct, then about 4.75 ft^3 CH_4 per lb. of destroyed volatile solids could be a credible production estimate.

The composition of the effluent produced from the Colorado project is shown in Table E-1.8.7. Additional research by R. B. Singh, et al. (1971, 1974) indicates that approximately 10 to 15 percent of the total nitrogen occurs as NH_3; they also observed that phosphorus (reported as P_2O_5) and potassium (reported as K_2O) composed from 0.6-0.8 percent w/w of the dry sludge. Handling this material will be discussed under plant design.

E. Existing Bio-Gas Facilities

From its initial demonstration at the London International Exposition in 1851, the bio-gasification concept has largely been utilized only in those areas suffering from severe natural or politically induced shortages of energy resources. During World War II the shortages of fuel in Germany led to the development of Schmidt-Eggersgluss and Weber-type methane plants in rural areas to supply gas for farm operations (Singh, 1971).

TABLE E-1.8.7--EXPECTED SLUDGE COMPOSITION FROM THE PROPOSED BIOGAS PLANT

	Raw Effluent	Dewatered Sludge
% Moisture	93.0	75.1
% Total Solids	7.0	24.9
% Volatile Solids (Dried)*	50.0	50.0
% Inerts (Dried)	50.0	50.0
% Nitrogen (Dry Wt.)	2.8	2.3
% Carbon (Dry Wt.)	28.7	29.2
% Hydrogen (Dry Wt.)	3.4	3.3
% Phosphorus	--	--

Source: Burford and Varani, Table 4-10--Data Derived from the Analysis of 44-Day Old Output

*Sample obtained by ashing dried solids, one hour each at 550°C.

The implementation of this process spread through Western Europe until fossil fuels once again became available. However, many French and German farmers continue to use home-scale digesters for fuel and fertilizer production.

The first attempt to produce CH_4 from cow manure appears to have occurred in Bombay, India in 1900. At about this time sewage treatment plants initiated sewage processing to improve effluent quality. Such efforts produced a flurry of laboratory and pilot-scale experimentation in England, Western Europe, and India during the 1920's and 1930's. The current focus of organic digester research is India, largely in response to the overwhelming need for raising the living standard of the rural poor in the face of escalating petroleum and fertilizer prices. Research into the production of cheap, clean fuel and fertilizer at the village level via simple waste recycling technology continues at the Gobar Gas Research Station at Ajitmal (Etawah District) in Northern India. Since its inception in 1958, progress in the improved biochemical engineering of fermentation plants has resulted in cost effective technologies that are quite adaptable to the needs of the proposed Glasgow IAF although both require similar equipment, bio-gas production is a simpler process to maintain than sewage treatment plant technology.

In the United States where the problem more often centers on waste disposal rather than waste use, anaerobic digestion has been limited to sewage treatment plants. In some cases the sludge is recycled on land or sold as fertilizer. The scrubbed gas is used to power pumps and electric generators in the plant. The Hypermion Sewage Treatment Plant in Los Angeles, California has been in operation since the mid-1940's and produces about 5 million cubic ft/day of bio-gas (3 million scfd of CH_4)--Ecotope, 1977. Half of the gas is consumed in large internal combustion diesel engines to produce electricity and heat for plant operation while the remainder is piped to a gas turbine-electric utility plant adjacent to the sewage treatment plant. The sludge was once used by a truck farm operation until urbanization of the area eliminated the market for this by-product.

The Agriculture Energy Corporation of Ludington, Michigan has operated a 350 head beef feedlot methane generator since 1974. The company offers a "turn-key" service; they can install the system for the user. The reactor tank is 22' wide, 110' long, and 6.8' to 8.8' deep and is plug-flow (gravity) loaded. Hydraulics are applied where possible to eliminate the need for more costly non-sparking electrical pumps, (Ecotope Group, 1977).

Although no operational data is available to MERDI researchers, it appears to be a very good system for small farm operators who cannot afford expensive sewage treatment hardware.

An alternative to the Ludington Plan is presented in the following discussion. The proposed system is basically a hybrid, utilizing portions of a number of process designs. The system presented below has neither been constructed nor tested, although preliminary calculations indicate that it should be successful (with the clear possibility of an engineering modification).

F. Plant Description

Bio-gasification design criteria are of two basic types: 1) size dependent, and 2) size independent. The first category indicates the amounts of available raw material(s), heating and mixing requirements, and available construction materials. The second category includes the types of input, minimization of operational problems, e.g., prevention of corrosion, safety hazard situations, optimal system design and construction, and others. In order to satisfy these design criteria, the plant should be simple in design, easy to construct and operate, and yet be technologically sound and cost-effective. These are primary considerations for the successful design and operation of a bio-gas facility at GAFB.

G. Digester Design

It is proposed that the digesters function as continuous-feed, displacement type bio-gas generators. This will assure a more or less continuous production of gas and sludge from the input of raw material. The interior of each tank is divided using concrete baffles in order that the addition of fresh slurry pushes partially digested material into a lower, adjacent chamber for further gas production. Gravity provides the overflow mechanism.

The 25 day solids retention time (SRT) design will require a total manure/straw slurry holding capacity of about 36,250 ft^3. Calculations of the area available in the A&E shop revealed that eight tanks (each having about 4,500 ft^3 operational volume) connected in series via piping from the mixing (large collection) basin should contain the manure/water/straw slurry input volume.

Assuming an average 1.4 scf/lb. manure volatile solids and 2.5 scf/lb. of straw, the gas production rate should be about 29,041 scf per day. If it is conservatively assumed that 55 percent by volume of the product gas is CH_4 and that methane's heating value is 1012 Btu/scf, then daily methane energy production will be about 1.62×10^7 Btu. If heat loss (conduction) from the tank's interior (98°F) to the atmosphere (75°F) is assumed to be 0.1 Btu/hr. ft^{-2}, then total heat losses are about 23,541 Btu/hr. or about 5.65×10^5 Btu/day (i.e., 3.5 percent is lost per day). The remainder of the gas, 1.56×10^7 Btu per day, is equivalent to 6131.0 horsepower (HP) or 4571 kilowatts (assuming a constant rate of gas production and using the conversion factors of 3.93×10^{-4} and 2.93×10^{-4}, respectively). Assuming a thermal to mechanical conversion efficiency of 25 percent and a mechanical to electrical conversion of 80 percent, then the expected total (daily) horsepower and kilowatt outputs are reduced to 1226 HP and 914.2 kw respectively. If the above magnitude of energy output is correct, the feedlot/bio-gas unit will contribute significantly to its energy self-sufficiency, as demonstrated in Table E-1.8.8.

The power requirements are not necessarily representative of average daily (or other unit time dimension) loading since most of the equipment will be operated only intermittently. Assuming that only the bio-gas related pumping machinery (including an estimated two HP pump for the algae culture operation) and grain storage climate control units are operated continually, then the estimated daily load should be met by the bio-gas plant. It is suggested that the bio-gas be completely converted into electricity, with the excess power fed (when available) into the ethanol process requirement(s) pool. The ethanol plant would "reciprocate" by providing emergency digester heat if the electrical generation system should fail.

TABLE E-1.8.8--PROJECTED ENERGY LOADING OF THE FEEDLOT/BIOGAS UNIT[a)]

Facility	Component	Estimated Horse Power	Estimated Wattage[b]
Grain Storage	Grain Conveyors (2)	20	880
	Ventilation/Air Conditioning (2)	25	880
	Straw Shredder	5	440
	Formula Mixer/ Agitator Screw	5	440
Feedlot	Pesticide Wash Pump	1	220
	Mechanical Agitator	5	440
	Sewage Lift Pump	2	880
	Reversible Slurry Pumps (8)	21	3520
	Heat Exchanger Pumps (8)	14	2358
	TOTAL	98	10,058 (i.e., 10.06 kw)

a) Instantaneous Power Requirements (Average loading to be expected to be about one-half the instantaneous requirement on an overall average).

b) Assumes wattage equals voltage times one ampere.

H. Digester Operation

The manure/water/straw slurry enters the bio-gas plant (possibly) through a ball valve (to check back pressure from the digesters) and is preheated by ethanol column process water exiting from the digester heating coil units. Because the design is a hybrid between a two-stage digester and a continuous digester, the passage of material through the tanks must be done in a manner that assures maximum gas production in a minimum amount of time (i.e., a short-as-possible SRT). A slurry processing schedule is outlined in Table E-1.8.9.

To initiate digester processing, seed material from a municipal digester or a well-rotted manure pit which contains an adequate population of both acid-forming and methane-producing bacteria is added to the mixing tank. The slurry is pumped into the digesters and purged of oxygen by displacing the digester atmosphere with CO_2 originating from the ethanol fermentation vessels. As a guideline, the seed material should be at least twice the volume of the fresh manure slurry during the start-up phase, with the daily addition of seed decreased (to none) over a three-week period. The digesters should be warmed about twice a day (one hour in both the morning and evening suggested) on a regular basis. The first and second cells of each digester are agitated 2 to 3 times a day for 15 to 20 minutes per mixing period, while the last two cells are not agitated in order to allow effective separation of the sludge from the thin slurry.

I. Gas Storage and Electrical Generation Facilities

Within one week of the initial seeding of the digester system, the production of low quality gas should begin to flow from the vessels and into a central storage tank.

In order to prevent air from entering into the storage system, the gas must be maintained at pressures at least equal to the "normal" (base) pressure. The base is about 2,755' above mean sea level. Barometric pressure decreases about one inch of mercury (column) per 900 ft. elevation gain; thus the pressure decreases from a sea level value of 29.92 inches to 26.87 inches or 0.898 atmosphere (at 32°F) at the base. The gas should be scrubbed of inpurities and dried prior to combustion in the proposed methane-fired diesel-electric generator plant.

TABLE E-1.8.9--PROPOSED PROCESSING SCHEDULE

Cycle Number	Cell Number(s)	Total Days	Percent of Total Gas Production
1	1 and 2	16-18	∿ 80
2	3 and 4	8-10	∿ 20

Note: 100% production is only 60-70% of the theoretical yield.

Assuming that ten percent of the total wet weight of the daily manure slurry input is volatized to gas, daily production will be about three tons. If the gas is contained in a concrete cylinder with a height of eight feet and radius of one foot and covered by a "floating" steel roof having a density of 0.2 lbs/inch^2, then the gas will be compressed to 0.916 atmospheres (at 32°F) or 371.6 inches of water (column gauge at 4°F). The tank could be filled to a one foot depth with water flowing from the methane digester heat exchanger system. If the through-flow temperature of the scrubber water is assumed to be 68°F, then the 24.4 gallons present would absorb about 0.31 lbs. of CO_2, if the two phases are allowed sufficient time to come to chemical equilibrium. Thus, even if this throughput was maintained constantly, minute-by-minute, the process would only remove about 2.13 percent of the CO_2 present in the cylinder (assuming the CO_2 content of the input gas is 35 percent by volume). The partial pressure of hydrogen sulfide, a pollutant, is so low (5 to 10 ppm) that absorption by the scrubber water is not an effective method for H_2S removal.

The cleaned gas is fed into the air intake of the engine with the pressure maintained so that the air:gas mixture does not pre-ignite. Methane is explosive when mixed with air in proportions ranging from 5 to 15 percent by volume; however, the compressed gas exiting storage will be of sufficient pressure to prevent dangerous flash-backs and to maintain proper feed as illustrated in Table E-1.8.10.

The injectors should be set at about 20 percent mixture, as compared to normal fuel (diesel) requirements. Assuming an average power capacity of 50 HP, the gas volume consumed per day is shown in Table E-1.8.11.

The diesel system should be capable of full loading without consuming gas faster than it is being produced. However, if a deficit should occur, there will be a small pressure drop in the storage container, with the possible injection of exhaust air from the diesel engine (during the upstroke phase) into the tank unless this is regulated with a check valve on the engine.

TABLE E-1.8.10--BIO-GAS CONSUMPTION RATE PER HOUR IN CUBIC FEET AND AIR REQUIRED FOR OPERATION OF DIFFERENT TYPE OF ENGINES

Sl. No.	Name of Engine	Fuel System	Cylinder and Cycle Details of Engine	Brake Horse Power	Horizontal or Vertical	Speed i.e. RPM	Dia. of Gas Supply Line	Gas Pressure in Water Col. Inch Req.
1	Stuart Engine Coupled with 250 Watts, 110 Volts, DC Generator, Made in England	Petrol Engine	Single Cylinder 4 Cycle	1 BHP	Vertical	High Speed 1,800	3/8"	2" to 4"
2	Onan Engine Coupled with 1 KVA 110 Volts AC Generator, Made in USA	Petrol Engine	Single Cylinder 4 Cycle	3 BHP	Vertical	High Speed 1,500	3/8"	2" to 4"
3	Kubota Engine Made in Japan	Powerine Engine	Single Cylinder 2 Stroke	5 BHP	Horizontal	Low 900	1"	1" to 3"
4	Kubota Engine Made in Japan	Kerosene Oil	Single Cylinder 4 Cycle	10 BHP	Horizontal	Low 600 to 700	1"	1" to 3"

System of Cooling	Gas Consumption (c. ft) Per Hour		Air in c. ft Required for		Working Efficiency of the Engine	
	Normal Load	Full Load	Normal Load	Full Load	Liquid Fuel	Bio-Gas
Air Cooled	16.5	18.5	95	108	250 Watts	225 Watts
" "	48.0	58.0	264	318	1,000 Watts	850 Watts
Water Cooled	82.0	95.0	--	--	5 HP	4.03 HP
" "	155	175	--	--	10 HP	.2 HP

Source: Ram Bux Singh Bio-Gas Plant: Generating Methane from Organic Waste, 1971, p. 60.

TABLE E-1.8.11--PRESENTATION OF GAS PRODUCTION: CONSUMPTION BALANCE[a)]

	Day	Hour	Comments
Gas Production	29,041[b)]	1210	
Gas Consumption			
50 HP equivalent	22,683	945	Normal Loading
50 HP equivalent	25,600	1067	Full Loading

a) Assuming constant gas production and engine consumption rates for a diesel system requiring 155 scf/hr. and 175 scf/hr. per 8.2 HP at normal and full loading, respectively.

b) All gas volumes given in scf on a per unit time basis.

J. Offal/Slaughter-House By-Product Processing

Given an estimated 3.5 tons of waste(s) per process day (for about 21 days) with an assumed composition of 20 percent total solids at 12 percent (dry wt.) N, plus a non-lignin C/N ratio of 4.1:1, 20 times the weight of the slaughter house solids in wheat straw will be required to maintain a C/N ratio of 30:1. One hundred pounds of dry offal would thus have 12 lbs. of N and 49.2 lbs. digestible (non-lignin) carbon. One ton of dry wheat straw has ten pounds N (at 0.5 percent N dry wt.), and 655 lbs. digestible (non-lignin) C, a C/N ratio equivalent to 150, assuming that 45 percent of the available carbohydrates are in a form subject to quick microbial attack. Using these figures, the adjusted offal/straw feedstock C/N ratio is about 32.9;1 on a dry weight basis. If it is assumed that the straw moisture content is 10 percent w/w, then 15.4 tons of milled straw (ground to pass through a 2 mm screen) must be mixed with 3.5 tons of offal/by-products to maintain the above ratio (each day). A 1:1 dilution with water will increase the total weight to at least 34.3 tons.

With a total digester holding capacity of 747.5 tons, the offal/straw/water slurry can be easily accommodated. However, the waste material input will disrupt the ordinary manure processing schedule. In order for CH_4 production to begin at any significant rate, the material must reside at least ten days in the digester (regardless of changes in temperature or nutrient-related parameters). There should be no more than three days during which the manure supply is near zero (as could occur while penning new cattle and butchering the old). This could result in offal material displacement (before microbial attack has been initiated to any great degree) by a fresh manure slurry. Intolerable levels of methane-former washout, with possible bio-gas system collapse, might then occur.

There are two alternatives to this problem. The first involves the construction of a 100' x 50' x 5' evaporation bio-oxidation pond, possibly lined with 30 mill, reinforced Hypalan sheeting and bedded on a 6 to 12" layer of packed bentonite. The necessary pond volume would have to be at least 818,698 gallons (using densities of 10.0 lbs. per gallon for solid wastes and 8.34 lbs. per gallon for water). Assuming an average volume of 74.8 lbs. per cubic foot of wastes, the above volume (in gallons) would occupy about 21,220 cubic feet; note that the annual average rate of evaporation is assumed to be sufficiently high that the solids per process period can be sufficiently dehydrated then removed prior to the input of wastes from the proceeding process period.

The second alternative would be to load the digesters with a fraction of the total wastes and process the rest in the bio-oxidation pond. The material (input to the vessels) will not be completely digested, but since the straw content is so high, it is probable that the gas volume produced will be about the same as if the usual manure/straw slurry tonnage was digested.

K. Slurry (Supernatant) and Digested Sludge Production and Handling

Because approximately ten percent (w/w) of the total manure slurry input is volatilized to gaseous products, the weight of the output will be reduced to 90 percent of the input, while the volume will be the same (assuming no leakage losses). The digester tanks are designed so that the finished material will be a sludge (8 percent w/w water content) while the remainder will be a thin slurry supertant (with no more than 7 percent w/w solids). A schedule for digested sludge handling is outlined in Table E-1.8.12. The digested sludge production rate is about 17.5 tons or 786 cf.) from the methane fermentation vessels per day. The total output weight is 32.4 tpd and occupies the same volume as the input (1450 ft^3).

It is proposed that each fermenter tank be integrated into a centralized screw-type conveyor that feeds into a collection basin/pump system.

The warm sludge could be pumped into a tanker truck and hauled to an evaporation pond. This holding volume could either be one of the existing sewage lagoons or a newly constructed evaporation pond. The dried (processed) material would be removed later from designated storage and transported (as a crumbly solid) to local market(s) to be sold as a nutrient-rich fertilizer.

The solids thus dewatered contain approximately 30 to 40 percent of the total nitrogen that was input to the digestor units. The anaerobic

TABLE E-1.8.12--FINISHED SLUDGE HANDLING SCHEDULE ON A DAILY BASIS[a)]

Component	Approximate Composition (Tons)	Usage
Thick Sludge[b)]	21.1 Total (3.80 Water; 17.30 Solids)	Solar Dried Material Stored Prior to Local Field Application
Thin Slurry[c)]	11.3 Total (10.51 Water; 0.79 Solids)	Pumped to Algae-culture Tanks

a) Calculated from data in Table 7; assumes 1.3:1 solids:liquid input ration

b) 18 percent water, 82 percent solids

c) 93 percent water, 7 percent solids

micro-organisms themselves consist of 12 percent (w/w) nitrogen. As was discussed earlier, this anaerobic residue will initially go back to agricultural farmland as a fertilizer which would substitute for manure on a ton-for-ton basis at an equal moisture content. This material would also perform well as an organic base for lawn and garden fertilizers if the material were dried down to a moisture content of less than 15 percent.

L. Thin Slurry Processing

In addition to the anaerobic sludge, the digester tanks will also release a "thin" (7 percent solids, estimated) effluent or supernatant. Given an estimated composition (dry weight basis) of 1.8 to 2.4 percent nitrogen, 1 to 2 percent phosphorus and 0.6 to 0.8 percent potassium, this fluid probably cannot enter a municipal sewage treatment system without prior treatment. If this effluent is to be recycled through the bio-gas process, dissolved and suspended solids must be carefully controlled so as to prevent toxic substances (e.g., NH_4^+ and metabolic waste products) from eventually reaching concentration levels which would adversely affect digester efficiency. It is proposed that a "biological filtration system" might economically purify the effluent and provide a nutritive by-product that could also be mixed into the usual feed formula. A high-protein, single-cell algae-culture would provide harvestable biomass while disposing of thin slurry (see Table E-1.8.13).

M. System Design

The slurry removal system is designed so that the bulk of the overall sludge output (i.e., decomposed fibrous organic materials, including bacterial floc, plus inorganic minerals or ash) will settle by gravity. This material, described above, will be used as a fertilizer. The thin slurry and fibrous scum are decanted from the surface of the last cell within each digester tank.

The digester tank gate release mechanism is activated, allowing the fibrous scum and thin slurry to slide into the steel weir mounted inside the decanter tank. The scum is trapped on the screen (and is removed periodically) while the slurry percolates into the collection volume below the screen. The loading rate will be sufficiently slow

TABLE E-1.8.13--CHEMICAL COMPOSITION OF SPIRULINA MAXIMA

(Percent Dry Weight)

Protein	62-70
Fat	2-3
Carbohydrate	16-18
Moisture	3
Ash	6

Source: John L. Burford, Jr. and Fred T. Varani, Table 7-14, p. 7-33.

to allow the settling of some of the residual (filtrable) solids prior to pumping the slurry to the algae-culture tanks. Approximately 11.3 tons per day of thin slurry, containing 93 percent water, will weigh 7 percent more than water per unit volume. This will yield 2,534 gallons of effluent per day. Thus, each decanter unit must have at least a 320 gallon (about 43 cu. ft) storage capacity, since the bio-gas plant will have eight operational units. Because the scum is bulky and requires considerable space to store and handle, an additional 30 percent capacity should be added to the above calculated tank volume(s). The settled thin slurry liquid is then pumped through a common feed line into the algae-culture tank/greenhouse system.

N. Algae Selection and Culture Methods

Algae are unicellular plants that, when exposed to satisfactory lighting and nutrient conditions, convert CO_2 and water into carbohydrates through photosynthesis. If adequate sunlight, nitrogen/phosphate nutrient levels, and appropriate temperature and pH conditions exist, the algae will reproduce themselves nine times per day at peak growth rates (Burford and Varani, 1976).

The algae-culture in the ponds will obtain their nitrogen from the ammonium or nitrate ions dissolved in the effluent; it has been estimated that from 60 to 70 percent of the original nitrogen content of the cattle wastes is present in the thin slurry. The exposure of the fluid to the ambient atmosphere will oxidize significant portions of the phosphorus input to biologically available phosphate ions. Available carbon sources are bicarbonate (HCO_3^-) ions in the slurry and low pressure CO_2 piped from the ethanol fermentation facility. If the data given in the Bio-Gas of Colorado, Incorporated, study is linearly extrapolated to meet the envisioned design requirements of the GAFB complex, then it is predicted that about 7.9 tons (wet weight) of the bluegreen algae _Spirulina maxima_ (Lake Chad Strain) could be grown during each cattle processing (approximately 120 day) period. Alternative algae of approximately equivalent nutritional value is _Chlorella vulgaris_. Both _Spirulina_ and _Chlorella_ can be cultured and handled in the same manner.

The algal biomass would be harvested weekly. The moisture content could be reduced via passive or active solar dehydration before transportation to storage as a cattle feed supplement; an alternative would be to convey the biomass as a slurry to the cattle pen area (for direct consumption).

0. Process Description

The pumped thin slurry, (resembling heavily silted, muddy to brownish-black water) will enter a 130' x 22' x 1' (deep) culture pond. This will produce a volume rise equal to a little over one-half the tank's height. Initially, a seed culture (probably obtained from a commercial, biological supply house) will be added to the tank; after this addition, the algal population should be self-maintaining.

The pond will be enclosed in a wooden-framed greenhouse structure (135' x 42') in which the south and east-facing walls and roofs (constructed so that the pitch will capture even the lowest-angled winter solar radiation) are formed of double-glazed fiberglass (e.g., acrylic glazing, Rohaglass SDP16). The fiberglass tends to diffuse the incoming light, spreading it evenly to all corners of the pond area. It also traps the longwave solar radiation, and therefore aides in the maintenance of constant temperature, day or night. The present south-facing wall will be painted black during the construction phase; it will hopefully contribute to the regulation (or at least absorption) of ambient heat during biomass growth periods. In the summer months, ratchet-type or push-type ventilation panels set at or near the juncture of the fiberglass roofing and present wall area will be left open so that heated air rises from the building by convection and is replaced by cooler, more dense, air entering through the open vents.

The pond walls will be constructed of three to five inch reinforced concrete and will support a 30 mill, reinforced Hypalon^R liner to eliminate leakage and aid in the heat absorption process (this should also moderate the slurry's daily temperature cycle). The CO_2 distribution system could be of one inch diameter cold water type PVC pipe with holes punched on the lower side (to prevent plugging by the settling algae) for gas release into the surrounding fluid. The volume of the slurry will increase incrementally each day to a maximum of 2034 cf, (or about 0.72 feet in depth) by the end of the culture period. It will then be drained, largely via auto-or-gas-floatation, onto (and then through) the sand filter. The harvested algae would be carefully scrapped off the filter's surface with a garden rake and piled prior to dewatering. The "filtrate" is then pumped back to the feedlot area to serve as process water. Because of the approximate 66-day interval between production, the algae should be amenable to solar drying to a cake (having up to 35 percent solids by weight). Burford and Varani suggest that

> "The lowest level of use for the algae would be to put the six percent solids slurry into the digester for increased gas production. The next higher level use would be to use this slurry as a liquid fertilizer. The algae contain about eight percent nitrogen and would have to be cut into the soil to allow for decomposition to take place. The highest level use of this material would be as a cattle feed ingredient. To be used for this purpose the algae would have to be dried to 12 to 30 percent moisture depending on storage and preservation requirements. It is expected that the use of the algae as cattle feed will prove, in the long term, to be the most significant benefit of a large bio-conversion facility. Alternative uses of the algae are numerous and present the potential for its use as the raw material for several biological processes to produce sugar, acetic acid, ethyl alcohol, and other significant commercial products."

Nutrient and growth conditions vary with locale and culture-media. The data presented below, gathered through Los Alamos Scientific Laboratories research, should, nevertheless, be very similar to projected values at the IAF. These data will be useful in preparing algae/cattle feed formula blends for cattle consumption.

Table E-1.8.14 shows that, in general, microbial proteins are low in methionine, or have inbalances in either the leucine-isoleucine ratio or arginine and lysine levels. Thus, supplementing the feed ration with casein (milk protein) using powdered milk mixed into the formula may be of help in correcting such deficiencies. Studies using laboratory rats indicate that Spirulina feed is highly digestible. It has a high protein (conversion) efficiency ratio and biological value relative to casein or whole egg. Additional data on vitamin content, fatty acid composition, and mineral composition can be found in the Four Corners Commission document on bio-gasification in the southwest.

TABLE E-1.8.14 --ESSENTIAL AMINO ACID COMPOSITION OF FRESH BEEF, CHLORELLA VULGARIS, AND SPIRULINA MAXIMA[a)]

Amino Acid	Beef	Chlorella Vulgaris	Spirulina Maxima
Arginine	6.6	15.8	11.7
Histidine	2.9	3.3	3.8
Isoleucine	5.1	3.5	6.0
Leucine	8.4	6.1	8.0
Lysine	8.4	10.2	4.6
Methionine	2.3	1.4	1.4
Phenylalanine	4.0	2.8	5.0
Threonine	4.0	2.9	4.6
Tryptophan	1.1	2.1	1.4
Valine	5.7	5.5	6.5
TOTAL	48.5	53.6	53.6

a) All values are expressed as the percentage contained in the crude protein extract (N x 6.25).

Source: Burford and Varini, Table 7-15, pp. 7-31.

E-1.8.5 Summary

An integrated agricultural facility at Glasgow Air Force Base can be housed in Buildings #666 and #667. Building #666 will contain grain storage, cattle pens, manure collection, and meat processing. Building #667 has available space for eight bio-gas generators and an ethanol processing plant. These buildings and their IAF components will be connected via conveyor belts, pipes, and tunnels to fully integrate their respective functions. A greenhouse algae-culture structure and a bio-oxidation pond (or possible sewage lagoons) may be additionally sited adjacent to the existing structures.

The integration of a cattle feedlot with an ethanol plant, bio-gas generators, and algae-culture can be scaled to meet the needs of a particular region. The combination of these components will yield outputs of ethanol/gasohol, meat, hides, fertilizer, and feed. The operation largely can be built and maintained by a local work force, thus generating employment opportunities; however, a professional engineer (having a broad scientific background) probably will be required to supervise the overall activities at the complex.

Agricultural integration, as defined above, may prove to reduce the costs of any single component operation, e.g., a cattle feedlot or an ethanol plant. The cycling of so-called "wastes" is already occurring in many countries, and these waste cycles can help decrease U.S. dependence upon fossil fuel inputs into agricultural production while reducing or eliminating adverse environmental consequences and pollution.

Finally, it should be noted that simultaneous removel of both SO_x and NO_x from the furnace waste gas stream can be implemented via a solution of a suitably formulated and pH-buffered mixture containing sodium bisulfite and other compounds (e.g., water-soluble catalysts). Depending upon the waste gas flow rate through the scrubber system, the number of scrubber stages utilized, the temperature and composition of the scrubbing solution, etc., "efficiencies of 60 to 90 percent (removal) from a stream contrining 1000 to 2000 ppm NO_x have been achieved" (R.G. Neville in Considine, et al., p. 9-319). It is believed that an appropriate scrubber unit in combination with appropriate furnace and burner design (see S.A. Johnson and A.H. Rawdon in Considine, et al., pp. 9-335 to 9-348) could reduce the nitrogen oxide emission levels to levels below state and federal ambient air quality or emission regulations.

However, regardless of the control system ultimately utilized at the base, space (or volume) must be allocated to store the products of the scrubber (gas emission control) system prior to regeneration or eventual disposal of a "throw-away" material. If the latter case becomes true, temporary storage may be suitably provided in the ash holding pond.

E-2.0--LEGAL REQUIREMENTS

E-2.1--INTRODUCTION

Legal material not presented in the main body of the text is examined in this section of Appendix E. Specific legal requirements are given for the development of the ethanol plant, wind facility, and coal gasification re-uses. The rail car facility and modular housing re-uses have virtually no additional laws governing their establishment other than those discussed in the main body of the text.

E-2.2--LEGAL REQUIREMENTS AFFECTING MOST OF THE RE-USE ALTERNATIVES

E-2.2.1 Special Considerations

Montana Environmental Policy Act (69-6501 et seq., R.C.M. 1947) and National Environmental Policy Act (42 USC 4321 et seq.).

A. Policy

These laws are virtually identical in their statement of policy and directions to administrative agencies. The laws declare a state (national) policy of encouraging "productive and enjoyable harmony between man and his environment" and direct state (federal) agencies "to use all practicable means, consistent with other essential considerations of state (national) policy, to improve and coordinate state (federal) plans, functions, programs, and resources" to achieve the environmental goals of the acts (69-6503, R.C.M. 1947; 42 USC 4332).

B. Environmental Impact Statements

Although both the state and federal laws contain many broad policy statements and specific directives to state and federal agencies, the only provision of the laws which has attracted much attention is the directive that every state (federal) agency must

> "Include in every recommendation or report on proposals for projects, programs, legislation, and other major actions of state (federal) government significantly affecting the quality of the human environment, a detailed statement on
>
> (i) the environmental impact of the proposed action,
> (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
> (iii) alternatives to the proposed action,
> (iv) the relationship between local short-term use of man's environment and the maintenance and enhancement of long-term productivity, and
> (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented."

Agencies are directed to circulate these impact statements to other agencies and to the public for comment, and the EIS must "accompany the proposal through the existing agency review processes" (69-6504, R.C.M. 1947; 42 U.S.C. 4332).

C. State Use of Federal EIS's

Provisions in state EIS regulations authorize state agencies to adopt and incorporate by reference EIS's previously prepared by federal agencies on related projects. The state EIS then may take the form of an addendum to such a pre-existing EIS. In appropriate circumstances, joint state-federal teams may be formed to conduct joint reviews of projects which will require both state and federal action.

D. EIS Procedures

State and federal EIS procedures are similar in overall approach although they differ in detail. Federal regulations vary from agency to agency. All state agencies with EIS responsibilities have adopted uniform regulations, which vary only in some of the fee provisions (e.g., Department of Health regulation at A.R.M. 16-2.2(2)-P2000).

When a proposed project is originated in an agency or presented to a permit authority by an applicant, a preliminary environmental review (PER) is prepared to determine whether the impacts of the proposed action will be significant enough to require the preparation of an environmental impact statement. If a negative determination is made, a written declaration to that effect is issued, with reasons, and processing of the proposed action continues. If the PER (EIA) indicates that there will be significant impacts, the responsible officials must prepare a draft environmental impact statement (DEIS).

State regulations require the agency to notify an applicant within 30 days after the application is filed if an EIS will be required. If so, the applicant will be requested to submit an estimate of the project's cost so that a fee can be assessed.

There are no uniformly applicable time limits for preparation of the DEIS, although specific state statutes impose overall time limits on agency reviews (e.g., Clean Air Act, Water Pollution Control Act). When the DEIS is completed, it is reviewed within the agency and then circulated to the public for review and comment. State regulations allow 30 to 45 days for comment. Extensions of these periods are available on request. A public hearing may be held after adequate notice if public controversy or the nature of the proposed action make it appropriate.

Following the comment period and hearing, a final EIS (FEIS) will be prepared which contains new or amended information and responds to issues raised during the comment period. State regulations provide that if no substantive comments are received and no new issues are raised, the DEIS also may serve as the final statement.

No final action on the proposal may be taken sooner than 60 days after circulation of the DEIS nor sooner than 30 days after circulation of the FEIS.

E. Fees

State agencies are authorized to assess fees from applicants for permits or licenses to help meet the costs of preparing EIS's on such permit applications. Such fees may be assessed only if the cost of preparing the EIS will exceed $2,500. The law sets a schedule of maximum fees based on the estimated cost of the project being reviewed. Unexpended fee monies are returned to the applicant. The EIS fee rule does not apply to applications under the Major Facility Siting Act or the Water Use Act. (Those laws contain separate fee provisions.) Furthermore, when fees are collected for review of sewage, solid waste, and water supply systems under the Sanitation in Subdivisions Act, those fees must be credited against the EIS fee assessment (A.R.M. 16-2.2(2)-P2060(f)).

E-2.2.2 Major Facility Siting Act (70-801 et seq., R.C.M. 1947; Regulations: A.R.M. 36-2.8(1)-S800 et seq.)

This state law provides for the comprehensive review of the siting and construction of major facilities engaged in generation, distribution or conversion of energy. Such facilities must receive a Certificate of Environmental Compatibility and Public Need from the Board of Natural Resources and Conservation before construction may commence.

The Act applies, inter alia, to the following facilities:

- plants designed for, or capable of, producing 25 million cubic feet of gas per day;
- plants designed for, or capable of, generating 50 megawatts of electricity or more;
- plants designed for, or capable of, utilizing, refining, or converting five hundred thousand (500,000) tons of coal per year;
- electric transmission lines (for lines ten miles or less, the threshold is 230 kilovolts); and
- pipelines for transporting water, gas, or liquid hydrocarbons to or from a facility as defined above.

The review procedures also cover "associated facilities" such as transportation links, diversion dams, storage ponds, transmission substations, and other devices and equipment associated with the production or delivery of the energy or product produced at a facility. The Act does not apply to facilities under exclusive federal jurisdiction.

Under the Act, a "utility" means any entity engaged in any aspect of the production, storage, sale, delivery, or furnishing of heat, electricity, gas, hydrocarbon products, or energy in any form for ultimate public use.

A. Application Procedures

Implementation of the Major Facility Siting Act is the responsibility of the Board of Natural Resources and Conservation, a quasi-judicial lay board appointed by the governor. Actual administration of the Act is the responsibility of the Montana Department of Natural Resources and Conservation (DNRC) which reports to the Board. It is the Board which ultimately grants or denies certification of facilities.

No one may commence construction of a facility without making application to the Board of Natural Resources and Conservation for a Certification of Environmental Compatibility and Public Need. ("Commence to construct" means the initiation of any physical clearing, excavation, or construction work, or the commencement of eminent domain proceedings.) Applications are submitted to DNRC's Energy Planning Division. The DNRC has two weeks to notify the applicant whether the application is complete.

B. Application Contents

Applications must include a description of the facility and its proposed location with a discussion of alternative sites; a statement of the need for the facility with projections of future demands, efforts to promote energy conservation, with discussion of reasonable alternative energy sources; summaries of existing environmental studies; and the applicant's efforts to mitigate adverse impacts.

C. Fee

An application fee is assessed based on the estimated cost of the facility. The applicant must submit an estimate and analysis of engineering and construction costs. The schedule of maximum allowable fees is as follows:

2% of the first $1,000,000 of estimated cost of the facility
plus 1% of the next $19,000,000;
plus 1/2% of the next $80,000,000;
plus 1/4% of the next $200,000,000;
plus 1/8% of the estimated costs over $300,000,000.

The fee money is to be used by DNRC to compile the information required for rendering a decision on an application and to carry out its other responsibilities under the Act. The applicant is entitled to an accounting of the monies expended and a refund of unexpended funds. The applicant may contract with DNRC for the generation of information or provision of other services in advance of filing the application. Money paid to DNRC under such a contract will be credited against the filing fee.

D. Notice of Intent

An applicant may file a Notice of Intent to file an application in advance of filing or formal application. The notice must contain most of the information required in the application. The Department has two weeks after receipt of a notice to determine its adequacy. If an adequate Notice of Intent is filed 12 months in advance of the formal application, the applicant is entitled to a five percent discount on the filing fee.

E. DNRC Study

Upon receipt of the completed application, DNRC conducts a thorough study and evaluation and reports to the Board with recommendations. This report must be made within two years of receipt of the application (one year for transmission lines and pipelines of less than 30 miles). During this period, the departments of Health, Highways, Fish and Game, and the Public Service Commission also conduct studies (using portions of the fee money) and report their findings to DNRC.

F. Board Hearing

The Board of Natural Resources and Conservation sets a hearing date within 120 days of DNRC's report. Parties to the hearings may include the applicant, DNRC, affected municipalities and their residents, and interested environmental organizations. The hearing is conducted under the contested case provisions of the Administrative Procedures Act (82-4209 through 4217, R.C.M. 1947), and the burden is on the applicant to justify granting of the certificate.

G. Board Finding

The Board must make its decision within 90 days after the conclusion of the hearing. The certificate may not be granted unless the Board finds that the following standards have been met:

1. the facility represents the minimum adverse environmental impacts with respect to land use patterns, water resources and quality, air quality, solid waste disposal problems, radiation, and noise;
2. the facility is consistent with regional plans for expansion of utility grids;
3. the facility complies with applicable state and local laws and regulations;
4. the Department of Health and Environmental Sciences and the Board of Health have certified that the facility will not violate state and federal air and water quality standards and implementation plans; and
5. the facility serves the public interest, convenience, and necessity and satisfies an identified need (this finding refers only to public utilities). In making this determination, the Board must consider the need, environmental impacts, benefits to the applicant and to the state, the effects of resulting economic activity, and the effects on public health, safety, and welfare.

The Board must issue a written opinion; the certificate, if granted, must include an environmental evaluation statement discussing unavoidable adverse impacts, objections raised by other agencies, alternatives to the facility, monitoring plan, and a statement of agreement by the applicant to abide by any conditions imposed. The Board may, however, waive provisions if an emergency showing is made. Any party may appeal the Board's decision to district court.

H. Long-Range Plans

Every public utility or other party contemplating the construction of a facility during the subsequent ten years must file an annual long-range plan with DNRC. This plan must be filed by April 1 each year and must include, to the extent it is available, the following information:

1. the approximate date of filing the formal application;
2. description of the general location, size, and type of facility planned;
3. projections of demand for the services to be provided by the facility;
4. description of efforts to involve environmental protection and land-use planning agencies in the planning of the facility; and
5. other efforts to mitigate environmental impacts.

Such long-range plans also must be filed with the Environmental Quality Council, the Department of Health and Environmental Sciences, the Department of Highways, the Public Service Commission, the Department of State Lands, the Department of Community Affairs, and interested citizen groups. DNRC may begin its study and evaluation of any such facilities which are proposed for construction within five years.

I. Unified Procedures

The law states that if a certificate is granted under this Act, no other state or local agencies may require any other permits or licenses. The Board of Natural Resources has the authority to overrule local ordinances in appropriate situations. In practice, however, the Board will require compliance with local regulations. In addition, permits will be required from other state agencies (e.g., air and water pollution discharge permits, and water use permits). The effect of the law is to aid in unifying and coordinating the review procedures of the various agencies rather than to eliminate the permit requirements of those agencies. Thus, the air, water, solid waste, and other reviews discussed below may be carried out concurrently and in coordination with the Department of Natural Resource's studies under the Siting Act.

E-2.2.3 Air Pollution Control (42 U.S.C. 7401 et seq., 69-3904 et seq., R.C.M. 1947; Regulations: 40 C.F.R. Part 60; A.R.M. 16-2.14(1)-S1400 et seq.)

Montana's air pollution control program is established in the Clean Air Act of Montana, which is designed to satisfy the requirements of the Federal Clean Air Act, as amended. Montana has been delegated primary enforcement responsibility by the Environmental Protection Agency (EPA), although variances, hazardous emissions, certain new source performance monitoring, and some other special procedures are subject to EPA approval. Federal facilities are required to comply with all aspects (procedural as well as substantive) of state implementation and permit programs.

A. Permit Procedures

Permits are required for both construction and operation of a pollutant source. Pre-construction permits are required for emission-producing equipment and facilities of the following types and in the following industries (*inter alia*):

- power generation plants;
- chemical plants;
- fertilizer manufacturing;
- fossil fuel-fired boilers;
- biological materials processing;
- grain processing; and
- coal processing.

Construction permit applications must be filed with the State Department of Health and Environmental Sciences (DHES) at least 180 days before commencement of construction.

Applications for operation permits must be filed at least 120 days prior to operation and must be accompanied by plans, specifications, process descriptions, and any other information required by DHES. DHES has 30 days to determine if the application is complete. Once a complete application is received, DHES has 60 days to make its decision or up to 180 days if an environmental impact statement must be prepared. Any person adversely affected by a DHES decision may, within 15 days, request a hearing before the Board of Health under the provisions of the Administrative Procedure Act. Board decisions may be appealed within 30 days to district court. If construction is not completed within two years after the permit is granted, a new permit will be required.

Permits will be granted only after a showing that the facility will not violate ambient air and emission limitation standards. The Air Quality Bureau of DHES may require the applicant to provide sampling and monitoring facilities. Before granting an operation permit, the Air Quality Bureau must find that the facility was constructed and installed in accordance with the conditions imposed by the construction permit.

B. Equipment Malfunctions

Malfunctions which will increase emissions and will continue for more than 24-hours must be promptly reported to the Air Quality Bureau. The AQB may approve continuation of operations for up to ten days. Additional time may be granted for major equipment failures if a corrective program is submitted and approved. All malfunctions lasting for four hours must be reported within seven days with information relating to volume of excess emissions caused, corrective actions, etc.

C. Variances

The Board of Health and Environmental Sciences may, after public hearing, grant variances from emission limits or other standards. Such variances are reviewed annually for renewal. A fee is assessed for a variance application based on the cost of the equipment which would be required to bring the facility into compliance with the rule from which the variance is sought. The fee is applied to the cost of hearings, environmental impact statements, and other expenses occasioned by the application.

D. Emergency Episodes

Montana's emergency episode plan is designed for emergency control of particulates and sulfur dioxide. There are four air pollution episode stages: forecast, alert, warning, and emergency. At the forecast stage, major pollution sources are notified that an atmospheric stagnation advisory is in effect. As pollutant concentrations rise, increasingly more stringent enforcement actions may be taken, including partial or total shutdown of pollution source operations. Enforcement orders will remain in effect until ambient pollutant concentrations fall below the emergency episode levels.

E. Standards and Limits

State ambient air quality standards and emission limits may be more stringent than federal requirements and may be stricter in some localities because of unusual concentrations of emission sources, population, or because of the nature of the economy or land-use patterns in an area. Air quality standards must be achieved by continuous emission controls such as stack gas scrubbers, rather than dispersion controls such as tall stacks, or intermittent controls such as production cuts during atmospheric inversions.

F. Non-Attainment Areas

Many areas of the country have not achieved compliance with the national ambient air quality standards. Subsequent to the statutory 1975 deadline for such compliance, the EPA developed an "emission offset" policy under which construction permits for new industrial sources in non-compliance areas could be issued only if increases in air pollution from the new source are more than offset by emission reductions from existing sources in the area, beyond those reductions required by the application implementaion plan. The 1977 amendments accept this offset policy and extend the deadlines by which states must attain the primary ambient air quality standards. States are required to revise their state implementation plans (SIP's) by January 1, 1979 to provide for the attainment of primary standards by December 31, 1982. In areas where automobile emissions present a special problem, the deadline may be extended to 1987; states are authorized to adopt transportation control plans to deal with the problem.

At the present time, GAFB does not lie within a non-attainment area.

E-2.2.4 Emission Standards (A.R.M. 16-2.14(1)-S148C)

A. Odors

Emissions of gases, vapors, or odors must be controlled so as not to create a public nuisance. Operations which discharge odor-causing material into the outdoor atmosphere must install and maintain odor control devices or procedures as specified by the Air Quality Bureau.

If a public nuisance is created, the operation may be required to tightly close and ventilate the facility so that all emissions are treated for destruction of odor-causing materials.

B. Fluorides (A.R.M. 16-2.14(1)-S14060)

Emission limits for fluorides apply to any process, other than aluminum reduction, which may cause a release of fluorides into the outdoor atmosphere from any storage pond, settling basin, ditch, liquid holding tank or conveying device. The established emission limit is 108 milligrams per squared centimeter every 28 days (measured by calcium formate paper method).

C. Sulfur Oxides: Sulfur in Fuels (A.R.M. 16-2.14(1)-S1470)

Liquid or solid fuels containing sulfur in excess of one pound per million Btu fired may not be burned. Gaseous fuel containing sulfur compounds in excess of 50 grains per 100 cubic feet of fuel may not be burned.

These restrictions do not apply to 1) waste gas incineration, if gross heating value is less than 300 Btu per cubic foot; or 2) fuel use where gaseous combustion products are used as raw materials for other processes.

A permit may be granted to burn fuels with higher sulfur contents than those indicated above if the facility is fired at a rate of one million Btu per hour or less.

On application to the Department of Health, fuels with higher sulfur content than those indicated may be used if mixed with lower sulfur-content fuels such that the mixture does not violate the criteria, and SO_2 control processes are applied which reduce SO_2 emissions to acceptable levels.

D. Visible Contaminants (A.R.M. 16-2.14(1)-S1450)

Visible air contaminants darker than #2 on the Ringelmann Chart or of a greater opacity are prohibited from any installation. No single source may discharge any air contaminants darker than #1 Ringelmann or of a greater opacity. If the presence of uncombined water is the only reason for noncompliance, these rules do not apply.

E. Particulates (A.R.M. 16-2.14(1)-S1430 et seq.)

1. From Incinerators

Particulate emissions may not exceed 0.1 gram per standard cubic foot of dry flue gas. Emissions may not exceed 10 percent opacity of #½ on the Ringelmann Chart. Only multiple chamber incinerators or approved equally effective types may be used to burn refuse. The Air Quality Bureau must approve all incinerators before installation or use.

2. From Industrial Processes

Particulate emission limits, given in Table E-2.2.4.1, do not apply to fuel burning equipment, incinerators, fossil fuel-fired steam generators, or sewage treatment plants if federal new source performance standards have been adopted for such sources.

Table E-2.2.4.1

Particulates

Industrial Processes

Process Weight Tons/Hr	Emissions lb/Hr	Process Weight Tons/Hr	Emission lb/Hr	Process Weight Tons/Hr	Emission lb/Hr
0.05	0.551	2.50	7.58	25.00	35.4
0.10	0.877	3.00	8.56	30.00	40.0
0.20	1.40	3.50	9.49	35.00	41.3
0.30	1.83	4.00	10.4	40.00	42.5
0.40	2.22	4.50	11.2	45.00	43.6
0.50	2.58	5.00	12.0	50.00	44.6
0.75	3.38	6.00	13.6	60.00	46.3
1.00	4.10	8.00	16.5	70.00	47.8
1.25	4.76	9.00	17.9	80.00	49.0
1.50	5.38	10.00	19.2	100.00	51.2
1.75	5.96	15.00	25.2	500.00	69.0
2.00	6.52	20.00	30.5	1000.00	77.6
				3000.00	92.7

NOTES: Interpolation for process rates up to 60,000 lb (30 Tons) per hour shall be accomplished by using the equation:

E = 4.10 P**0.67

for process weight rates in excess of 60,000 lb (30 Tons) per hour, use the equation:

E = 55.0 P**0.11 - 40

E = Emission Rate in Pounds per Hour.
P = Process Weight Rate in Tons per Hour.

3. Airborne Particulate Matter

Material handling, storage, or transporting shall not cause particulate matter to become airborne. Buildings, roads, driveways, or open areas (e.g., loading docks, freight yards) may not be constructed, used, repaired, or demolished unless all reasonable measures to prevent airborne particulates have been taken. Such measures include paving, frequent cleaning of roadways, application of dust-free surfaces or of water, and maintenance of vegetative ground cover.

4. Fuel Burning Equipment

Discharges of particulate matter by fuel combustion from stacks or chimneys may not exceed the hourly rates. Heat input is calculated as the aggregate heat content of all fuels whose combustion products pass through the stack or chimney. When two or more fuel burning units are connected to a single stack, their combined heat input shall not exceed that allowable for the same unit connected to a single stack.

Through the prevention of Significant Deterioration of Air Quality (PSD), New Source Performance Standards (40 C.F.R. Part 60), the 1977 amendments to the Federal Clean Air Act established a revised regulatory scheme for review of major new sources of air pollution and land classification schemes for maintenance of high air quality in those regions where air quality is already above national standards.

F. Land Classifications

Under the classification scheme, land areas in which minimal increments in pollution levels would be allowed may be designated Class I areas; areas in which moderate increments would be allowed as Class II; and areas in which substantial increments in pollutant levels would be allowed (so long as ambient air quality standards are not violated) as Class III. Allowable increments are measured with respect to baseline pollutant levels as they existed in August 1977.

Certain special federal areas, such as national parks and wilderness areas, have been designated Class I. All other areas of the country have been designated Class II. After public hearings and consultation with federal land managers, the states have the power to redesignate Class II areas as either Class I or Class III. Each state must revise its state implementation plan to include procedures for redesignating areas and for assuring that increment levels are not violated. Montana is presently in the process of developing such procedures. Until they are adopted, applications for redesignation of areas are made directly to the EPA.

To date, the Northern Cheyenne Indian Reservation in southeastern Montana is the only region in the country which has been redesignated Class I as a result of application to the EPA. That pristine air designation has already caused some problems for the proposed power plants at nearby Colstrip. If the Fort Peck Indian Reservation should be granted a similar redesignation, major facilities in surrounding areas, such as at GAFB, would be subject to stringent scrutiny to assure that the Reservation's Class I increment levels are not violated.

G. New Source Review

In addition to area redesignation procedures, states also are required to adopt review procedures for major new sources of pollution. Again, until such regulations are adopted by the state, new source review is subject to EPA approval.

A "major stationary source" subject to the new source performance standards is defined as any source which, in the absence of pollution control equipment, would have the potential to emit 250 tons per year of any pollutant for which ambient air quality standards or emission limits have been set. In addition, the standards apply to sources with an emission potential of 100 tons per year in a number of designated categories, including:

- fossil fuel-fired steam electric generating plants with a design capacity of more than 250 million Btu per hour heat input;
- coal cleaning plants (with thermal driers);
- fuel conversion plants;

- incinerators;
- chemical process plants;
- fossil fuel boilers with design capacity of more than 250 million Btu per hour heat input; and
- petroleum storage and transfer units with capacity of more than 300,000 barrels.

In general, major new sources must satisfy a number of requirements including the following:

- application of best available control technology (BACT) for control of pollution;
- compliance with all applicable emission standards;
- demonstration that the source will not violate ambient air quality standards or allowable increments;
- continuous monitoring of ambient air quality by the operator;
- analysis by the operator or projected impacts on visibility, soils, vegetation, economic growth, etc.; and
- public hearings on the proposed facility.

Sources which, after application of controls, are expected to emit no more than 50 tons per year, 1,000 pounds per day, or 100 pounds per hour of pollutants and which will have no adverse impacts on Class I areas or non-attainment areas must meet all emission standards but are exempt from the BACT requirement, the ambient air quality monitoring requirement, the impact analysis requirements, and the demonstration that allowable increments will not be violated.

H. New Source Performance Monitoring (40 C.F.R. 60.7 et seq.)

In addition to the state agency permit procedures described above, operators of major new sources must notify the EPA of

- commencement of construction (within 30 days after);
- the anticipated initial start-up date (between 30 and 60 days prior); and
- commencement of monitoring system (at least 30 days in advance).

Performance tests must begin within 60 days after achieving the maximum production rate but no more than 180 days after the initial start-up.

1. New Source Performance Standards: Fossil Fuel-Fired Steam Generators (40 C.F.R. 60.40)

The performance standards applicable to fossil fuel-fired steam generating units of more than 250 million Btu per hour heat input are contained in Table E-2.2.4.2. These performance standards must be met no later than the performance tests described above.

The nitrogen oxide standards do not apply when fossil fuel containing more than 25 percent by weight of coal refuse is burned in combination with other fossil fuels. However, cyclone-fired units which burn fuels containing 25 percent of Dakota or Montana lignite remain subject to the standards regardless of the fuel combination.

Continuous monitoring systems must be installed and maintained by the operator to measure capacity, SO_2 and NO_x emissions.

2. New Source Performance Standard: Incinerators (40 C.F.R. 60.50)

This standard applies to any incinerator which is charged at a rate of more than 45 metric tons per day. Particulate discharge may not exceed .18g/dscm (.08gr/dscf) corrected to 12% CO_2.

E-2.2.5 Water Pollution Control (33 USC 1251 et seq., 69-4801 et seq., R.C.M. 1947; Regulations: 40 C.F.R. 100, 400; A.R.M. 16-2.14(10)-S14460 et seq.)

The Federal Water Pollution Control Act--FWPCA (33 USC 1251 et seq.) creates a wide range of responsibilities at both the federal and state level with the ultimate objective of achieving clean water throughout the nation. This act is based on water quality standards which were developed primarily by the states and effluent limitation requirements which have as an objective the elimination of all pollution by 1983. To achieve these goals, the states are required to develop long-range planning processes which will coordinate discharge permit systems, waste treatment programs, maximum pollution load limits, etc. Once the state's planning process and permit system are approved by the EPA, the state has primary responsibility

Table E-2.2.4.2--New Source Performance Standards: Fossil-Fuel Steam Generators (greater than 250 Btu/hr)

	Emission Limits
Particulates:	.1 lb/million Btu; 20 percent opacity
SO_2:	.8 lb/million Btu (liquid fossil fuel)
	1.2 lb/million Btu (solid fossil fuel)
NO_x:	.2 lb/million Btu (gaseous fuel)
	.3 lb/million Btu (liquid fuel)
	.7 lb/million Btu (solid fuel)

for enforcing the water pollution control laws. Federal facilities then are required to comply with state laws and regulations, both procedural and substantive.

A. Permit Procedures (A.R.M. 16-2.14(10)-S14460)

The Montana Pollutant Discharge Elimination system satisfies the requirements of the Federal Water Pollution Control Act. It is unlawful, without a current permit, to construct or operate a disposal system or any sewage or waste discharge outlet which discharges into the waters of the state. The permit system applies only to point sources of pollution. Any wastewater holding or settling pond which is designed to, or may, discharge into state waters would be considered a point source requiring a permit from the DHES. Water impoundments which will not discharge into state waters are not subject to permit requirements. However, if such facilities have adverse impacts on groundwater quality (especially on aquifiers used as public water supplies), the DHES has authority to take whatever action is necessary to abate such impacts. Such holding ponds and other impoundments should be designed in consultation with DHES's Water Quality Bureau to avoid groundwater degradation.

B. Permit Applications

Application must be made at least 180 days in advance of the proposed operation. The application must contain facility plans, soil conditions, operating precedures, and any other information which the DHES deems necessary. Supplemental reports may be required for new sewage systems, treatment works, etc. or extensions of such facilities. Reports on sewage systems, treatment works, and sewage disposal systems should contain (as a minimum) the information outlined in the "Recommended Standards for Sewage Works" as adopted by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers. The application will not be processed by DHES until all required information has been received.

After the completed application is received, DHES makes a tentative determination based on effluent standards, performance standards, water quality standards, toxic and hazardous substance standards, and existing area-wide water treatment plans. If tentatively approved, a draft permit is issued which contains effluent limits, compliance schedules, operating conditions, monitoring requirements, etc. If discharges will be 500,000 gallons per day or more (or in other appropriate circumstances), DHES will prepare a fact sheet.

Public notice of the draft permit is issued, and a 30-day comment period is provided during which time requests for a public hearing are received. After the comment period and hearing (if any), the final determination is made. Permit approval requires the concurrence of the EPA regional administrator in Denver. Permits are effective for up to five years, and reissuance follows similar procedures. If DHES decides to modify, deny, suspend, or revoke a permit, opportunity for a hearing before the Board of Health must be provided. All decisions by the Board may be appealed to district court. An applicant's trade secrets may be designated confidential by declaratory judgement of the court.

C. Water Quality Standards

Montana has established water quality standards for all river basins throughout the state (A.R.M. 16-2.14(10)-S14480). These standards have been approved by the EPA and provide the fundamental rationale for all other aspects of the pollution control program. Effluent limitations, maximum load requirements, and waste treatment planning must be designed to meet water quality standards.

D. General Requirements

The water quality standards adopted by the Board of Health and Environmental Sciences require the best practicable treatment and control of waste, activity, and flow in order to maintain water quality at the highest possible levels. The degree of waste treatment required is determined on a case-by-case basis and is based on the state's non-degradation policy; present and anticipated beneficial uses of the water; the quality and nature of water flow; the quantity and quality of the discharge; and the presence or absence of other pollution sources.

Sewage must receive a minimum of secondary treatment, and industrial wastes must receive the equivalent of current Best Practicable Control Technology (BPCT) as defined by EPA.

Industrial sources may not discharge substances into surface waters which will settle, float, produce odor or color, create toxic concentrations, or create conditions which produce undesirable aquatic life.

The following temperature criteria are recommended for operation of water impoundments to enhance aquatic life: January and February: less than 40° F; June through September: greater than 44° F.

Waste treatment ponds may not be located in drainageways where drainage water volume from a ten-year storm exceeds one-half the pond's capacity.

Snow removal activities require a permit for dumping.

At least minimum treatment is required for discharges to dewatered streams until minimum stream flows are established or into intermittent streams.

Storm drainage, storm sewage discharges, and non-point source pollution should be eliminated or minimized.

Test and measurement methods shall comply with the latest edition of "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association.

Allowable levels of dissolved radiation concentrations are given in Table 2.2.5.1.

E. Specific Requirements

In addition to the general water quality standards which apply to all water in the state, the following criteria apply to the Milk River drainage in the vicinity of Glasgow (Water Classification B-D3).

Table E-2.2.5.1--Allowable Levels of Dissolved Radiation Concentrations

Average Dissolved Concentrations of Radiation
(Including Natural Background)

Element	Limit (Picocuries/Liter)
Iodine-131	5 PC/L
Radium-226	1 PC/L
Strontium-89	100 PC/L
Strontium-90	10 PC/L
Tritium	3000 PC/L
Other Radionuclides and Those with Suspended Material in Transport	1/150 of Amounts in Water for Continuous Exposure, National Committee on Radiation Protection (NBS Handbook 69 or Latest Revisions)
Mixtures	C1/L1+C2/L2...+CN/LN </= 1.0 Where C = Avg. Concentration; L = Limit
Where Alpha Emitters, SR-90, RA-228, I-129, I-130 and PB-210 are Absent	100 PC/L

Water quality must be maintained suitable for drinking, culinary, and food processing purposes after adequate treatment equal to coagulation, sedimentation, filtration, disinfection, and additional treatment necessary to remove naturally present impurities; for bathing, swimming, and recreation; for growth and propagation of non-salmonid fish and associated aquatic life, waterfowl, and furbearers; and for agricultural and industrial water supply.

The following temperature variations are allowable:

- within the natural range 32°-77°F, a 3° increase above natural is allowed;
- within the range 77°-79°F, discharges shall not cause temperatures to exceed 80°F;
- for natural temperatures above 79.5°F, a 5° increase is allowed; and
- for natural temperatures above 32°F, a 2° per hour decrease is allowed.

Coliform Bacteria--Using the membrane filter technique, the number of coliform bacteria shall not exceed one per 100 ml. (monthly arithmetic means of all samples).

For limits when other procedures are used or where fewer than four samples are taken per month, see 40 C.F.R. 141.14.

Radiation--Maximum contaminant levels for radiological contaminants are given in Table E-2.2.5.2

Table E-2.2.5.2--Maximum Contaminant Levels for Radiological Contaminants in Water

Constituent	Level PCI Per Liter
Combined radium-226 and radium-228	5
Gross alpha particle activity (Including radium-226 but excluding radon and uranium)	15
Tritium	20,000
Strontium-90	8
Gross beta radioactivity	50

The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body of any internal organ greater than 4 millirem per year.

F. Effluent Limitations

Section 301 of the FWPCA established target dates for achieving effluent discharge controls. By July 1977, point sources other than publicly owned treatment works were to apply "best practicable control technology currently available," and public treatment works were to utilize secondary treatment techniques. By July 1983, point sources other than public treatment works are to apply "best available technology economically achievable" and should achieve elimination of pollution discharges if technologically and economically possible, and publicly owned sewage treatment works are to apply "best practicable waste treatment technology."

Section 302 provides that where necessary to maintain water quality standards and to protect public water supplies, fish and wildlife, and agricultural needs, more stringent effluent limitations must be applied. Areas in which effluent limitations described above are not sufficient to implement water quality standards are to be given priority ranking, and maximum daily pollutant loads are to be established at levels necessary to achieve those standards (§ 303(d)). New sources of pollution in various industrial categories are required to apply "best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable... no discharge of pollutants" (§ 306(a) (1)). Control of toxic substances discharge also is established (§ 307). Amendments to the law in 1977 extended the deadlines for compliance with many of these standards.

G. Drinking Water Standards (40 C.F.R. 141.11 et seq., A.R.M. 16-2.14 (10)-S14381)

Public water supplies are subject to special contaminant limitations. Major pollutant sources whose discharges may affect public water supplies should be aware of these limits. These are identified and quantified in Table E-2.2.5.3

Table 2.2.5.3 --Contaminant Limitations (Drinking Water)

Inorganic Chemicals (other than fluoride)

Contaminant	Level Milligrams Per Liter
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (ssN)	10.
Selenium	0.01
Silver	0.05

Fluorides

When the annual average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the maximum contaminant levels for fluoride are:

Temperature Degrees Fahrenheit	Degrees Celcius	Level Milligrams Per Liter
58.7 and below	12.0 and below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4

Organic Chemicals

	Level Milligrams Per Liter
(a) Chlorinated hydrocargons:	
Endrin (1,2,3,4,10, 10-hexachloro-6,7-epoxy-1,4, 4a,5,6,7,8,8a-octa-hydro-1,4-endo, endo-5,8 - di-methano naphthalene).	0.0002
Lindane (1,2,3,4,5,6-hexachloro-cyclohexane, gamma isomer).	0.004
Methoxychlor (1,1,1-Trichloro-2, 2 - bis (p-methoxyphenyl) ethane).	0.1
Toxaphene ($C_{10}H_{10}Cl_8$-Tochnical chlorinated camphene, 67-69 percent chlorine).	0.005

Table E-2.2.5.3--Contaminant Limitations (Drinking Water) (Continued)

Organic Chemicals (Continued)

	Level Milligrams Per Liter
(b) Chlorophenoxys:	
2,4 -D, (2,4-Dichlorophenoxyacetic acid).	0.1
2,4,5-TP Silvex (2,4,5,-Trichlorophenoxyproplonic acid).	0.01

Turbidity--Maximum turbidity allowed for drinking water is one turbidity unit (TU), monthly average, and five TU's average for any two consecutive days.

Up to 5 TU's monthly average may be allowed if the supplies of water can demonstrate to the state that the higher turbidity does not do any of the following:

1. interfere with disinfection;
2. prevent maintenance of an effective disinfectant agent throughout the distribution system; or
3. interfere with microbiological determinations.

H. Effluent Standards: Specific Sources and Effluents, Organic Chemicals; Acetone, Butadiene, Ethyl Benezene, Ethylene, Propylene, Formaldehyde, Methanol (40 C.F.R. 414--see Table E-2.2.5.4).

1. Pretreatment Standards (40 C.F.R. 128)

When wastewaters are discharged into municipal sewage systems utilizing publicly owned wastewater treatment works, such wastes are subject to pretreatment standards. Federal pretreatment standards apply to "major contributing industries," i.e., users of publicly owned treatment works which

- have an average daily flow of 50,000 gallons of wastewater;
- have a flow greater than five percent of the total volume carried by the municipal system;
- have toxic pollutants in their waste; or
- have significant impact on the treatment works, as determined by the pollution discharge permit agency.

The following wastes may not be introduced into the public system:

- wastes which create fire or explosion hazards;
- wastes which will cause corrosive or structural damage to the treatment works (e.g., pH lower than five);
- solid or viscous wastes in amounts which would obstruct the sewers or otherwise interfere with the operation of the treatment works; and
- wastes discharged at excessive flow rates over short periods of time.

Table E-2.2.5.4--Effluent Standards

Effluent Characteristics	Effluent Limitations Maximum 1 Day			(KG/1000 KG of Product) 30-Day Average		
	A*	B*	C*	A*	B*	C*
COD		.8			.58	
BOD_5	.13	.044	.11	.058	.025	.048
TSS	.20	.066	.10	.088	.040	.044
pH	Within the 6.0 to 9.0 Range					
Acetaldehyde						
COD		1.32			.95	
BOD_5	.95	.32	.76	.42	.18	.34
TSS	1.42	.48	.72	.64	.29	.32
pH	Within the 6.0 to 9.0 Range					
Methyl Amine						
COD		.39			.21	
BOD_5	.22	.062	.16	.1	.034	.88
TSS	.22	.098	.098	.1	.052	.052
pH	Within the 6.0 to 9.0 Range					

*Standards are expressed in three ways:

A. Pollutant level after application of best practicable control technology currently available.

B. Effluent reduction attainable by application of best economically available control technology.

C. New source performance standards.

Except as required by the criteria above, special pretreatment is not required for "compatible pollutants," i.e., chemical oxygen demand, total organic carbon, phosphorus and its compounds, nitrogen and its compounds, or fats, oils, or grease of animal or vegetable origin.

For non-compatible pollutants (i.e., all those not listed as "compatible") pretreatment standards are established in effluent limitation guidelines defining best practicable control technology for appropriate pollution source categories.

The pretreatment standards described above and listed in effluent guidelines are minimum requirements. State and local authorities may require more stringent controls, depending on special conditions in the locality. The Glasgow treatment works officials must, therefore, be consulted to ascertain special restrictions.

2. Secondary Treatment (40 C.F.R. 13.3)

Standards applicable to effluents discharged by publicly owned treatment works after application of secondary treatment as defined by the EPA are contained in Table E-2.2.5.5. If discharges by major industrial sources into a public treatment system would interfere with the attainment of these standards, the industrial discharges may be restricted accordingly.

E-2.2.6 Solid Waste/Hazardous Waste (69-4001 et seq.., R.C.M. 1947; Regulations: A.R.M. 16-2.14(2)-S14100 et seq.)

The Solid Waste Management Bureau of the DHES is responsible for administering the state's solid waste and hazardous waste management programs. These programs are designed to comply with the requirements of the Federal Resource Conservation and Recovery Act (42 USC 6901 et seq.). Federal facilities are required to comply with all state and local laws and regulations and with EPA guidelines (40 C.F.R. 241: Guidelines for Land Disposal of Solid Wastes; 40 C.F.R. 243: Guidelines for the Storage and Collection of Residential, Commercial and Industrial Solid Waste). The decision on how the requirements of the guidelines will be met is made by the responsible federal agency.

Table E-2.2.5.5 --Secondary Treatment Standards for Publicly Owned Treatment Works

Effluent Characteristic	Effluent Limitations	
	30-Day Average	Maximum 7-Day Average
BOD	30 mg/l	45 mg/l
	15% of influent values	
TSS	30 mg/l	
	15% of influnet values	45 mg/l
pH	6.0 to 9.0	

A. Solid Waste

Solid wastes from a gasification plant will be primarily ash and sludge produced by the Lurgi process. If the intention is to dispose of this waste at the coal mine associated with the gasification plant, approval must be obtained from the Department of State Lands (DSL) as part of DSL's review of the mining and reclamation plan.

If the wastes cannot be disposed of at the mine (because potential leaching problems may degrade water quality), the wastes must either be incinerated or disposed of at an approved sanitary landfill.

Only Class I landfills can accept industrial wastes. Such facilities must

- confine wastes so they do not escape;
- be located so that leachate or run-off cannot reach surface or groundwaters;
- be fenced to prevent animals from roaming;
- receive one foot of earth cover daily; and
- be supervised during open hours.

B. Licensing Procedures

A license from DHES is required to dispose of hazardous or solid waste, to transport hazardous waste, or to operate a solid waste management facility. This requirement does not apply to disposal of non-hazardous waste on one's own land if such land is at least five acres in size.

The application must include the location of the proposed facility and the plan of operation and maintenance. DHES regulations list criteria relating to fencing, supervision of the facility, daily covering, site selection (size, access, water pollution potential, soils, flooding potential, drainage), operation and maintenance. The EPA publication "Sanitary Landfill Design and Operation" (SW-65ts) is referred to for guidance.

Within 15 days after receipt of an application, DHES must notify the local health officer who has jurisdiction in the area where a proposed solid waste facility is to be located. DHES also notifies the local health officer in writing if it decides to issue a license.

The license is not valid until signed by the local health officer who must decide whether or not to validate it within 15 days. Issuance or validation of a license may be refused or revoked by DHES or the local health officer only on a finding that the facility will not comply or is not complying with the requirements of this law or any rules adopted by DHES under this law. Such decisions can be appealed to the Board of Health within 30 days.

C. Hazardous Waste

Under EPA definition, hazardous waste means any waste or combination of wastes of a solid, liquid, contained gaseous, or semi-solid form which may cause or contribute to an increase in mortality or an increase in serious illness, taking into account the toxicity of the waste, its persistence and degradability in nature, and its potential for assimilation or concentration in tissue. If the waste contains any "hazardous substances" so defined, special regulations will apply.

Generators of hazardous waste must comply with federal standards respective to record keeping, labeling containers, and use of a manifest system to assure that all hazardous waste is designated for treatment, storage, or disposal in a licensed facility.

Transporters of hazardous waste must also comply with record-keeping and labeling requirements and with the manifest system mentioned above.

Operators of hazardous waste treatment, storage, and disposal facilities must obtain operating permits and must comply with record keeping, reporting, monitoring, and performance requirements.

The EPA is presently developing a list of hazardous wastes and hazardous waste treatment standards. The state Solid Waste Management Bureau will be authorized to administer the program and enforce the regulations.

If an application under the Major Facility Siting Act contemplates generation, transportation, storage, or disposal of hazardous wastes, DHES is to conduct the review required by this law in conjunction with the air and water quality reviews required by the Major Facility Siting Act.

E-2.2.7 Noise

There are no generally applicable outdoor environmental noise limitations in effect in Montana. Local governments may establish noise regulations as part of their zoning ordinances; these would be checked locally.

Construction work at federal work sites under GSA contract is subject to the limits set forth in Table E=2.2.7.2. Federal facilities must comply with all state and local regulations.

A. Standard Noise

The Federal Noise Control Act (42 USC 4903) requires federal agencies to comply with state and local noise control laws and regulations.

DHES regulations establish allowable noise levels as contained in Table E-2.2.7.2.

E-2.2.8 Occupational Safety and Health (41-1708 et seq., R.C.M. 1947; Regulations: A.R.M. 16-2114(6)-S14280 et seq., 24-3.18A(2)-S1820 et seq.)

Programs designated to protect the health and safety of workers and to regulate noise and emissions in the work place are jointly administered by the Occupational Health Bureau in the DHES, the Health and Safety Bureau of the Worker's Compensation Division (WCD) in the state Department of Labor and Industry, and the Occupational Safety and Health Administration in the U.S. Department of Labor (OSHA).

DHES monitors occupational conditions, conducts on-site inspections, and surveys all work places for excesses of dust, gases, mist, noise, lighting, and heat; conducts biological sampling; and inspects dust gas control systems and ventilation.

A. Permits

The Board of Health establishes conditions for permits for the installation, alteration, or operation of machines and equipment which may contribute to occupational disease. The Board must make its decision on a permit within 90 days of receipt of the completed application.

Table E-2.2.7.1--Maximum Construction Equipment Noise Levels at 50 feet (DB(A))

Earthmoving		Materials Handling	
Front Loaders	75	Concrete Mixers	75
Backhoes	75	Concrete Pumps	75
Dozers	75	Cranes	75
Tractors	75	Derricks	75
Scrapers	80	Impact	
Graders	75	Pile Drivers	95
Trucks	75	Jack Hammers	75
Pavers	80	Rock Drills	80
Stationary		Pheumatic Tools	80
Pumps	75	Other	
Generators	75	Saws	75
Compressors	75	Vibrators	75

Table E-2.2.7.2--Maximum Allowable Noise Levels As Established by the Montana Department of Health and Environmental Sciences

Duration (hrs/day)	Sound Level (dBA)
8	90
6	92
4	95
3	97
2	100
1½	102
1	105
3/4	107
½	110
¼ or less	115

Source: Survey of Federal, State, and Local Laws and Regulations Affecting Siting, Construction, and Operation of the MHD ETF in Montana, Montana Energy and MHD Research and Development Institute, March 1978.

B. Enforcement and Penalties

Whenever DHES becomes aware of a violation, it may serve a notice and order on the violator and may require the violator to appear before the Board. Within 30 days of the order, the violator may, on his own, request a Board hearing. The Board will affirm, modify, or revoke the DHES order. The Board's decision is judicially reviewable. Penalties up to $1,000 per day may be levied.

C. Standards

Air Contaminants--DHES regulations set maximum allowable emission levels for an extensive list of air contaminants in the work place. (See A.R.M. 16-2.14(6)-S14310 for the complete list.)

D. Standards--Safety

The Montana Safety Act administered by the Health and Safety Bureau of the Workers Compensation Division of the Department of Labor and Industry requires employers to provide safe working conditions in conformance with the standards adopted under the federal Occupational Safety and Health Act (29 USC 668 *et seq.*, 29 C.F.R. 1903 *et seq.*). The law provides for periodic inspections by the Bureau and authorizes the issuance of enforcement orders. Variances from standards may be granted if a worker's safety is not endangered thereby. Under federal law, federal agencies must consult with the Secretary of Labor in designing an occupational health and safety program and assuring the adequacy of federal facilities.

E. Fire Inspection (69-1801 *et seq.*, 82-1201 *et seq.*, R.C.M. 1947; Regulations: A.R.M. 23-2.1B(1)-S1000 *et seq.*)

Building plans are reviewed by the State Fire Marshall. Buildings designed for public, commercial, or industrial occupancy must meet requirements relating to fire extinguishers, fire escapes, building structure and materials, exits, alarm systems, flue and chimney requirements, heating devices, electrical wiring and equipment, air conditioning, ventilating systems, refrigeration systems, flammable liquids, rubbish, open flame devices, vehicle parking, dust explosions, lightning protection, and other special fire hazards. The Fire Marshall issues permits and conducts inspections periodically.

Fire Marshall Bureau regulations have adopted by reference the standards promulgated by the National Fire Protection Association, the U.S. Bureau of Standards, and the American Insurance Association.

E-2.2.9 Water Diversions--Montana Water Use Act (89-865 et seq., R.C.M. 1947)

A. Permits for Appropriation of Water

Permit applications are submitted to the Water Rights Bureau of the Department of Natural Resources and Conservation (DNRC). When DNRC receives an application for an appropriation permit, it must give public notice by publishing the information in a local newspaper for three weeks unless it determines that the application will not interfere with existing rights.

Any objection to the application must be filed with DNRC between 30 and 60 days after the last public notice. (DNRC sets the specific deadline date.) If DNRC determines that the objection is valid, it must hold a public hearing.

A permit application usually must be granted or denied within 120 days after publication (or 180 days if a hearing is held). Time extensions up to 60 days are available if an environmental impact statement must be prepared. If the application is denied or modified, the applicant has the right to a hearing. The Department must approve a permit if the following criteria are met:

1. There are unappropriated waters in the supply source which are available in amounts and at times of the year required by the applicant;
2. the rights of prior appropriators will not be affected adversely;
3. the proposed means of diversion or construction are adequate;
4. the proposed use of the water is a "beneficial use;"
5. the proposed use will not interfere unreasonably with other planned uses or developments for which a permit has been issued or for which water has been reserved; and

6. an applicant for an appropriation of 10,000 acre-feet per year or more (or 15 cubic feet per second or more) proves by clear and convincing evidence that the rights of a prior appropriator will not be affected adversely.

DNRC may attach conditions to the permit regarding construction projects and rights of other appropriators and may issue temporary or seasonal permits.

An approved permit must be recorded with the county clerk and recorder and must be filed in DNRC's main office; it may be revoked if its conditions are violated. A certificate of water right will be issued when the applicant actually begins using the water; however, it will not be issued until existing rights of the area have been adjudicated. Until then, the certificate is provisional and might be changed if it is determined later that it interferes with existing rights. Once granted, water rights may be transferred only with DNRC approval.

B. Appropriation of Groundwater (89-2911 *et seq.*, R.C.M. 1947)

The Department and Board of DNRC have the responsibility for ensuring that water from aquifers is not depleted through excessive withdrawals. The Board may designate "an area of controlled groundwater use" for any area where 1) withdrawals exceed recharge rates; 2) excessive groundwater withdrawals are likely in the near future; or 3) there are significant disputes over water rights or amounts of water being used by appropriators. Following a hearing, the Board may limit withdrawals from a controlled groundwater area. Permits to withdraw water from such an area will be granted by DNRC only if it decides the requested withdrawal will not exceed the aquifer's capacity.

Outside of a controlled groundwater area, no permit is required for a well drawing less than 100 gallons per minute (but notice of completion of the well must be submitted to DNRC within 60 days). For larger wells or inside controlled groundwater areas, the permit procedures described for surface water diversions are applicable.

To prevent waste and contamination of groundwater, the Department regulates construction and maintenance of water wells. Wells which pollute groundwater or produce water which is not being put to beneficial use must be plugged or capped, and well drillers must inform DNRC of new wells.

C. Fees

Fees for water appropriation applications are based on the volume of water applied for: from $5 for less than eight acre-feet per year to $550 for 50,000 acre-feet per year or more. Whenever DNRC determines that review of a permit application for an impoundment of 10,000 acre-feet or more or for 15 cubic feet per second or more will require preparation of an environmental impact statement (EIS) under the Montana Environmental Policy Act, a fee may be assessed according to a schedule based on the estimated cost of the project. DNRC and the applicant may negotiate the amount of the fee and the use of environmental information produced by the applicant or a third party in preparation of the impact statement. However, when the water diversion is part of a project which is being reviewed under the Major Facility Siting Act, no EIS fee will be assessed in addition to the application fee under the Siting Act.

D. Diversions from Fort Peck Reservoir

In addition to state water permit requirements, the federal government asserts jurisdiction over use of water from the Fort Peck Reservoir. The Corps of Engineers may require the execution of a water contract before large volumes may be withdrawn. The exact nature and extent of this joint jurisdiction is unclear, but an applicant should seek to comply with both state and federal requirements.

E. Land Disturbances

Land and shoreline disturbances associated with construction and operation of water diversions, pipelines, etc. are discussed in the following sections.

E-2.2.10 Off-Site Activities

Off-site activities associated with the gasification plant will have impacts which must be considered. These activities include construction of the water diversion system pipelines to bring in water and to carry out natural gas, construction or upgrading of roads and rail spurs, erection of electric power lines, etc. Land disturbances and other impacts caused by these activities may be reviewed under the laws which follow.

A. Streambed Preservation (26-1501 *et seq.*, R.C.M. D47; Regulations: A.R.M. 36-2.2(2)-S210 *et seq.*)

For purposes of this act, a "project" is any physical alteration or modification of a natural, perennial flowing stream or its bed or banks which results in a change in the state of the stream in contravention of the state policy to maintain such streams in their natural state. The state Fish and Game Department monitors federal activities which adversely affect fish and wildlife resources.

B. Procedures

Any person planning a project must send written notice, including location, description, and general plan of the project, to the appropriate board of "supervisors:" the supervisors of the appropriate soil and water conservation district, if any; if not, to the board of county commissioners. The supervisors determine whether the proposed action is a "project" as defined by the law. If so, the applicant and the Fish and Game Department are notified within five days. The Department has five days to request an on-site inspection, after which the supervisors have 20 days to convene an inspection team consisting of representatives of the supervisors, the Fish and Game Department, and the applicant. The team members submit written reports within 50 days of the application, recommending approval, denial, or modification of the proposal. The supervisors review these reports and make their decision within 60 days of receipt of the application. The supervisors' decision is based on the purpose, necessity, sediment effects, interference with property, and available mitigative measures. Efforts must be made to minimize impacts on stream flow, fish habitats, etc.

Any inspection team member who disagrees with the decision of the supervisors may request the judge of the district court to appoint an arbitration panel consisting of three county residents. The panel must reach its decision in ten days, and its decision is binding on all parties. If the panel requires modification of the proposal, any additional costs will be borne by the party who benefits from it, as determined by the panel. Final decisions may be appealed within 30 days to the district court.

C. Dredge and Fill Regulations (33 U.S.C 40 et seq.; 33 U.S.C. 1344; Regulations: 33 C.F.R. 209, 120 et seq.)

Under the Rivers and Harbors Act of 1899 and the Federal Water Pollution Control Act, the Army Corps of Engineers has jurisdiction and permit authority over "all waters of the United States" with respect to dredging, filling, and discharging of materials into such waters. The Corps of Engineers and state water pollution control agencies coordinate their reviews. Permit authority over waters not meeting the traditional tests of navigability is delegated to states which have had permit programs approved by the EPA. Federal projects which have been authorized specifically by Congress are exempt from federal and state dredge and fill permit requirements provided that, prior to authorization of construction funds, Congress has considered an environmental impact statement (prepared and distributed pursuant to EPA regulations at 40 C.F.R. 230) which analyzes the effects of dredge and fill activities.

D. Procedures

Application is made to the district engineer of the Corps of Engineers. The application must include a complete description of the proposed activity: plans, site location, purpose, use, approvals required by other government agencies, and type of discharge, if any. A fee of up to $100 may be assessed. (Government agencies or instrumentalities need not pay the fee.) If an environmental impact statement is required, the applicant may be assessed the costs of its preparation.

If state approval is required, the district engineer will not approve the application unless the state does. If the state grants approval or if the state takes no action within six months, the district engineer may continue processing the application.

After reviewing the application for completeness, the district engineer issues a public notice and allows up to 75 days for receipt of comments. If comments or objections warrant it, a public hearing will be held. The district engineer's decision must be made within 30 days after the receipt of notice of withdrawal of objections, after the receipt of the record of the public hearing, or after the expiration of the waiting period after filing a final environmental impact statement, whichever event occurs last.

Approval generally will be granted if the project complies with the goals and standards of the National Environmental Policy Act, the Fish and Wildlife Coordination Act, the Historic and Archeological Preservation Act, the National Historic Preservation Act, the Endangered Species Act, and the Federal Water Pollution Control Act. The district engineer must consider the comments of the regional director of the Bureau of Sport Fisheries and Wildlife, the regional administrator of the Environmental Protection Agency, the local representative of the Soil Conservation Service, and the heads of appropriate state agencies.

E-2.2.11 Soil and Water Conservations Districts: Land Use Regulations (760109 et seq., R.C.M. 1947)

Conservation district supervisors may, after approval by the voters in the district, adopt land-use regulations in the interest of conserving soil and water resources and preventing and controlling erosion. If adopted, the regulations have the force of law and may include provisions requiring engineering projects, cultivation or grazing methods, retirement of highly erosive areas, and other provisions as necessary to carry out the purpose of the Act. The regulations must be uniform throughout the district. However, lands may be classified with respect to soil types, drainage, erosion, etc., and regulations may vary according to the land classification.

A. Enforcement

Supervisors may enter private lands to investigate charges of violations of the regulations. If such violations exist, the supervisors may petition the district court to require the land owner to perform necessary work or to allow the supervisors to have the work done at the land owner's expense. If the petition is granted, the court retains jurisdiction until the work is completed. The regulations apply to state lands within the district, and state agencies must cooperate in their enforcement.

To date, Conservation District land-use regulations have been adopted only in Lewis and Clark County. The district supervisors in the Glasgow area should be consulted to determine if such regulations are in effect in Valley County at the time the proposed project commences.

E-2.2.12 State Historic Preservation Act (81-2501 et seq., R.C.M. 1947)

The Montana Historical Society maintains a list of registered sites of historic archaeological, scientific, or cultural significance to the state. Sites must be on state land to be registered, but agreements may be entered with private land-owners to protect historic sites on private land.

The Historical Society may seek injunctions to prevent the destruction of registered sites. The injunctions may be granted for one year, during which time the Society may propose alternative plans to the parties involved which will alleviate the threat to the site.

E-2.2.13 Highway Right-of-Way Activities

A. Excavations

Written approval must be obtained from the board of county commissionsers, county road supervisor, or county surveyor for excavation or construction across public highways (32-4403, R.C.M. 1947).

B. Approach Permits (A.R.M. 18-2.6AI(1)-S615 *et seq.*)

Construction of approaches to public highways must be approved by the state Department of Highways. The request is made to the chief of the appropriate Field Maintenance Bureau, and a brief description of the proposed project, including site plan, etc. is submitted. The applicant meets with the bureau chief to discuss the project, and if significant environmental impact is anticipated, the applicant may be required to include an environmental impact statement with his application. If the project is to be located in an area of traffic congestion, the bureau chief must submit the application to the Department of Highways for approval. Department regulations include standards and requirements for design, use, materials, construction methods, and inspection of highway approaches and access driveways.

C. Right-of-Way Occupancy by Utilities (A.R.M. 18-2.6AI(6)-S6080 et seq.)

All public utilities and all common carrier pipelines have the authority to utilize public right-of-way, but proposals must be reviewed by the Department of Highways to achieve maximum public use of right-of-ways while protecting public safety and avoiding conflicts between utility needs and transportation needs. These regulations apply only to the federal aid highway systems and do not apply to utilities operated by local governments within city limits unless utility lines are proposed on federal aid right-of-ways. The Highway Department reviews utility proposals for conformance with minimum safety standards for proper drainage, vegetation maintenance, debris control, and traffic protection and for scenic enhancement.

D. Procedures

The utility submits a notice of proposed right-of-way occupancy, including plans and location, to the appropriate Field Maintenance bureau chief. If the plans conform to the standards set forth in the regulations, the bureau chief will approve them. If not, he will return the plans with written comments. The utility may resubmit the corrected plans or appeal the decision to the Board of Highway Appeals.

E-2.2.14 Construction of Utility Lines

City or town councils and boards of county commissioners have permit authority for laying water, gas, and sewer mains under streets, alleys, and roads (11-975, 16-1114, R.C.M. 1947). City councils regulate the construction of electric lines and poles (11-945, R.C.M. 1947). The law establishes standards for construction of power lines, poles, and insulation (24-101 et seq., R.C.M. 1947). The National Electric Safety Code, promulgated by the Department of Commerce, applies to such lines, and the Public Service Commission is responsible for its enforcement.

A. Electric Lines (70-301 *et seq.*, R.C.M. 1947)

Authorization is given to electric and telephone public utilities to construct lines along public streets and roads. Lines in new service areas must be constructed underground if it is technically and economically feasible. City councils may regulate the erection of poles and cables within city limits (11-945, R.C.M. 1947).

B. Natural Gas Pipeline Safety (49 U.S.C. 1671 *et seq.*)

This law establishes safety standards for pipelines which carry natural gas in interstate commerce. State agencies may enforce the standards under an agreement with the federal government.

C. Fertilizer Registration (3-1714.2 *et seq.*, R.C.M. 1947; Regulations A.R.M. 4-2.10(2)-S1020 *et seq.*)

Manufacture, distribution, and sale of fertilizers within the state is regulated by the Montana Department of Agriculture. Every brand and grade of fertilizer must be registered by the manufacturer before it may be distributed or sold. (A fertilizer need not be registered if the same brand and grade is already registered in the state.) The registration application must include a description of the brand and grade, the guaranteed analysis, the source of each plant food element, the name and address of the manufacturer, and a copy of the label.

All registered fertilizers must be properly labeled, showing weight, brand, grade, and guaranteed analysis.

A lisense is required to distribute fertilizer in the state. However, a basic product manufacturer who sells exclusively registered products to registrants or licensees is exempt from the license requirement.

E-2.2.15 Federal Projects

If the project is conducted by federal agencies, uses federal funds, or requires federal permits or licenses, the following special review procedures relating to wildlife and historic preservation will apply.

A. Historic Preservation (16 U.S.C. 470 et seq., Regulations; 36 C.F.R. 800 et seq.)

Prior to the approval of the expenditure of any funds or the issuance of any license or permit, federal agencies must take into account the effect of the proposed project on any property included or eligible for inclusion in the National Register of Historic Properties. The Advisory Council on Historic Preservation must be afforded an opportunity to comment.

B. Procedures

As early as possible in project planning, the federal agency must identify properties within the project area which are included or eligible for inclusion in the National Register. For each such property, the federal agency must determine whether the project will have any adverse effects. If no adverse effects are anticipated, the agency notifies the State Historic Preservation Officer and the executive director of the Advisory Council on Historic Preservation (ACHP). The executive director of the ACHP has 45 days in which to object to the agency's determination that there will be no adverse impact.

If the agency determines that there will be adverse impacts or if the director of the ACHP objects to the agency's negative determination, the agency prepares a case report; the ACHP and the State Historic Preservation Officer are notified, and a consultation process begins. This process includes on-site inspections, public hearings, and consideration of alternative actions and mitigative measures. If no agreement is possible, the agency may not continue with the project until a formal presentation has been made before the full Advisory Council. The Council must make its decision within 60 days from the request for review.

C. Wild and Scenic Rivers Act (16 U.S.C. 1283)

Federal agencies must review their administrative and management policies, regulations, contracts, and plans affecting lands under their jurisdiction which include, border on, or are adjacent to rivers in or eligible for inclusion in the Wild and Scenic River System. Particular attention should be given to timber harvesting, road construction, and similar activities. When an agency's activities may affect such areas, the secretaries of Agriculture and Interior should be consulted. The secretaries may grant easements through components of the Wild and Scenic Rivers System in accordance with laws applicable to the National Park and National Forest systems.

D. Fish and Wildlife Coordination Act (16 U.S.C. 662)

Whenever waters of any stream are to be diverted, impounded, channelled, or otherwise altered by a federal permit, the responsible party first must consult with the Office of Sport Fisheries and Wildlife in the Department of the Interior and with the head of the state fish and game agency with the objective of conserving wildlife resources. Reports from the Fish and Wildlife Service and the state wildlife agency regarding the effects on wildlife and suggested mitigative measures are to be included in the report made by the agency responsible for the project. This report also must include a discussion of justifiable means to preserve wildlife resources and must include the costs and benefits of the project to wildlife. The responsible agency may transfer funds to the Fish and Wildlife Service to conduct the necessary studies. These requirements do not apply to impoundments whose surface area is less than ten acres.

Adequate provisions must be made for the use of involved lands for conservation and management of wildlife. These plants must be approved jointly by the head of the responsible agency, the Secretary of the Interior, and the head of the state wildlife agency.

E. Endangered Species Act (16 U.S.C. 1531) (50 C.F.R. 407)

All federal agencies have a responsibility to conserve and protect threatened and endangered species and, in consultation with the Secretary of the Interior, must take action to ensure that agency activities will not unduly harm such species. Agencies are required to consult with the Fish and Wildlife Service and receive an opinion as to whether the project will affect the critical habitat of a threatened or endangered species. Federal agencies may not engage in projects which will jeopardize the species or its critical habitat.

F. Coal Mine

The location, operation, and reclamation of a surface coal mine is subject to the regulation of the Department of State Lands and the Board of Land Commissioners. If operations are to take place on state or federal land (or if state or federally owned coal is to be mined), state or federal leases must be obtained. The operations may require air and water pollutant discharge permits. If an independent power supply is required, review under the Major Facility Siting Act may be necessary, as will review of off-site land disturbances associated with utility line and road and railroad construction. The Coal Mine Code sets health and safety standards for the protection of workers at the mine.

E-2.3--SPECIFIC ETHANOL LEGAL REQUIREMENTS

E-2.3.1 Applicable Standards--Petroleum Liquid Storage (40 CFR 60.110 et seq)

The following air quality standards apply to storage vessels for petroleum liquids with storage capacity greater than 40,000 gallons.

If the true vapor pressure of the liquid is between 1.5 and 11.1 psia (inclusive), the storage vessel must be equipped with a floating roof, a vapor recovery system, or their equivalents.

If the true vapor pressure of the liquid is greater than 11.1 psia, the vessel must be equipped with a vapor recovery system or its equivalent.

The operator of any such storage vessel must keep records of liquids stored, temperatures, and pressure.

E-2.3.2 Registration of Fuels (40 CFR Parts 79,80)

Manufacturers of "motor vehicle gasoline" must register their products with the EPA before they may be sold. Presumably, a ten percent alcohol-gasoline mixture would be considered a motor vehicle gasoline for the purposes of these regulations. However, fuels which are in a research and development or test status or which are sold only to automobile or engine manufacturers for test purposes and which are not offered commercially to the public are exempt from the registration requirement.

Applicants for registration must submit information regarding additives, hydrocarbon composition, sulfur and trace element content, vapor pressure, distillation temperatures, octane number, and, to the extent known, public health effects and toxicity of combustion emissions. The registrant may be required to conduct tests regarding health effects and emissions.

Quarterly production reports must be submitted.

E-2.3.3 Commercial Feed Regulation (3-2025 et seq, R.C.M., 1947; Regulations: A.R.M., 4.14.100)

A permit from the Montana Department of agriculture is required to manufacture or distribute commercial cattle feed. All feed must be registered and bear proper labeling which shows weight, name, brand, guaranteed analysis, and directions for use.

E-2.4--SPECIFIC WIND FACILITY LEGAL REQUIREMENTS

E-2.4.1 Special Considerations (70-101 et seq., R.C.M. 1947; Regulations: MAC 38-2.14 (1)-S1400 et seq.)

The Public Service Commission (PSC) is charged with the supervision and regulation of public utilities in the state and is composed of five members elected from geographic districts. Members serve four-year terms, and vacancies are filled by the state's governor.

A public utility is defined as any entity that owns, operates, or controls plants or equipment within the state for the producing, delivering, or furnishing to other persons or entities heat, street, railway service, light, power (in any form or by any agency), water (for business, manufacturing, household use, or sewage), or telegraph or telephone service.

Public utilities are required to provide reasonably adequate service at reasonable rates. Books and records must be made available to the PSC for inspection on request, and annual reports of operations are submitted to the PSC. All records and reports in the PSC's possession are available for inspection by the public.

E-2.4.2 Rates

Public utilities must file rate schedules with the PSC; no changes in such rates may be made without approval of the PSC. Before approving a rate change, the PSC publishes a notice of the proposed change, announces a hearing date, and informs the public how to participate in the proceedings. The hearing is conducted under the contested case provisions of the Administrative Procedures Act, and the state's Consumer Counsel may participate. Temporary rate changes may be approved pending the hearing. If the PSC has taken no action within nine months after the requested changes are filed, the new rates become effective automatically. In setting rates, the PSC takes into account the expenses and capital of the utility, and the Commission may ascertain the value of the utility's property. The utility's advertising costs are not included as expenses in setting rates, except for advertising which encourages energy conservation or development of renewable energy sources. A utility may not charge more or less than the rates filed with and approved by the PSC.

E-2.4.3 Business Activities

The PSC may investigate all aspects of the management of a public utility's business and may regulate the issuance of securities by a utility. The utility must apply to the PSC for permission to issue or acquire securities. Such permission will be granted unless 1) it would be inconsistent with the public interest, 2) it would be for a purpose not permitted by the law, or 3) the aggregate amount of securities outstanding and proposed would exceed the fair market value of the utility's property. Notes of obligation for a term of no more than one year and for a principal amount of no more than five percent of the utility's outstanding securities may be issued without PSC approval.

E-2.4.4 Investigations

Either on its own motion or on the filing of a complaint alleging unfair, discriminatory, unreasonable rates, inadequate service, or unreasonable rules or procedures, the Commission may conduct an investigation and hold a formal hearing after which it may issue orders adjusting rates, procedures or service. The Commission may exercise subpoena powers in conducting such hearings. Temporary orders may be issued pending a hearing which must be held within 20 days.

Any interested party may appeal a PSC order to district court within 30 days. An injunction may be sought to stay the order pending trial, and the court may transmit such evidence to the PSC and await the Commission's redetermination based on such evidence.

Utilities are obligated to report all serious accidents which occur in the operation of a public utility; the PSC then must investigate them.

E-2.4.5 Electric Suppliers Territorial Act (70-501 et seq. R.C.M. 1947)

The purposes of this law are to avoid unnecessary competition among suppliers of electric power and to encourage the most economical provision of new service. In general, the law provides that new service areas should be served by the supplier with the nearest existing lines or, in the case of a new commercial or industrial customer, by the supplier who can provide service at the least cost. An electric supplier may file a complaint in district court if it believes that another supplier is violating the law.

E-2.4.6 Rural Electric Cooperatives (14-501 et seq., R.C.M. 1947)

This law authorizes the establishment and operation of cooperative associations for the provision of telephone and electric power service in rural areas. The members of the cooperative are its customers. Excess revenue is refunded to customers at the end of the year in proportion to their patronage.

Such a cooperative is empowered to do all things necessary to construct facilities for the generation, distribution, and sale of electric power. A board of directors is elected by the members to manage the organization.

Cooperatives established under this law must pay a yearly license fee of $10.00 per 100 persons served, but they are exempt from all other excise or income taxes and also are exempt from PSC regulation.

E-3.0--ENVIRONMENTAL IMPACT ASSESSMENT

E-3.0--ENVIRONMENTAL IMPACT ASSESSMENT

This section of Appendix E contains environmental analyses of varying complexity and completeness for those aspects of the natural environment that could arise through implementation of the particular re-use concept. For sake of brevity and with the sole exception of the EIS-like discussion presented for the Lurgi gasification/mine complex, the other re-use concepts discuss only those subject areas of particular concern or significance. However, EIS-like presentations for the non-Lurgi re-use alternatives have been prepared and will be provided by MERDI upon request. Thus, this section is limited to E-3.1, an assessment of the coal mine/gasification complex; E-3.2, an assessment of potential impacts to baseline air quality via implementation of the rail car repair facility; E-3.3, an assessment of the potential changes in audible noise baseline levels if the wind farm concept were implemented; E-3.4, those possible indirect land use impacts arising from providing the gasohol steam plant with the various potential fuel types; and E-3.5, the cropland areas utilized and envisioned land use impacts arising from the application of straw as a boiler feed source (for the gasohol plant).

A seven-phase approach was utilized in the development of the environmental impact(s) discussions: 1) baseline/technical review, 2) literature review, 3) submission of information to Ecological Consultants, Inc. (ECON) of Helena, Montana for analysis, 4) MERDI-ECON conferences, 5) MERDI review, 6) technical analysis, and 7) preparation of text discussing the analytical findings for each given re-use alternative.

1) Baseline data[1,2,3] describing the ambient GAFB environment was reviewed in conjunction with the development of technical descriptions detailing the proposed GAFB re-use alternatives.

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[1] Montana Energy and MHD Research and Development Institute, Glasgow Meteorology and Air Quality Analysis Report, 1978.

[2] Montana Energy and MHD Research and Development Institute, Water Quality, Wildlife, and Vegetative Studies: Glasgow Air Force Base Study Area, prepared by ECON, Inc., 1978.

[3] Montana Energy and MHD Research and Development Institute, Siting Energy Facilities at Glasgow Air Force Base, "Volume I: Description of the Existing Energy/Resource Environment in Montana," prepared for the Federal Energy Administration, 1975.

2) Literature pertaining to the particular re-use, e.g., previous environmental impact statements, academic studies, and corporate documents, were reviewed (see References).

3) A preliminary environmental analysis was developed by MERDI and was submitted, together with the technical descriptions, to ECON, a private consulting firm which completed a year-long baseline study (see Section E-5) of the GAFB area aquatic environment, terrestrial wildlife, and terrestrial vegetation (the remainder of the baseline information was either existing or completed by MERDI.

4) Conferences were held between MERDI and ECON personnel to discuss anticipated environmental impacts for each of the proposed re-use alternatives. Qualitative descriptions were developed and quantified according to the available literature, where possible. Visual abstracts were prepared using the Leopold Assessment methodology,[4] as presented in Appendix C. Several areas of concern (where noted) required the professional judgement of the evaluators.

5) Upon the completion of ECON's impact analysis, MERDI personnel examined the completed descriptions and matrices for the completeness and significance of the information.

6) ECON's information, having been screened for significance, was combined with the preliminary analyses completed by MERDI in order to develop generalized environmental impact predictions (Appendix C).

7) The technically oriented predictions of impact magnitude and intensity were summarized to the greatest extent possible in Appendix C (without undue sacrifice of accuracy or completeness). The more detailed technical/specialized language and quantitative information (where possible) was compiled in the environmental impact descriptions given in this section.

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[4] Leopold, Luna, _et al._, _A Procedure for Evaluating Environmental Impact_, U.S. Geological Survey Circular 645, Washington, D.C., 1971.

E-3.1--LURGI SYNTHETIC NATURAL GAS (SNG)/AMMONIA PRODUCTION COMPLEX AND ASSOCIATED MINE-ENVIRONMENTAL ASSESSMENT APPENDIX

A detailed technical analysis of the environmental impacts associated with the construction and operation of a Lurgi coal gasification/ammonia plant and associated mine complex is given in this section. The information contained in the analysis includes light duty vehicle emissions, Lurgi flare-off emissions, Prevention of Significant Deterioration Class I (PSD I) air quality standards, reclamation activities, and Lurgi air pollution events.

E-3.1.1 Introduction

The following discussion is provided to further the reader's understanding of at least some of the salient adverse or beneficial environmental impacts that could arise if this re-use concept of Lurgi coal gasification (and associated strip mining activities) were to be implemented. The conversion (SNG/ammonia) complex is assumed to be located on relatively flat (0-5% slopes), vacant acreage within the confines of Glasgow Air Force Base (GAFB). It is further assumed that the magnitude of coal feedstock requirements (22,425 tons per day--tpd--for 345 days per year--dpy) would justify the establishment of a new lignite strip mine within a reasonable rail haulage distance from GAFB. For sake of example, the hypothetical mine will be located on the east side of the Nelson Creek Divide (i.e., T20N, R45E) in McCone County, Montana (see Figure E-3.1.1). There appears to be approximately ten sections of strippable "S" bed coal, having an average of 21,698 tons per acre[1] (Matson 1970).

Given the scope of the overall project (plus the lack of particular engineering parameters for the conversion facility and uncertainty in the mine permit area) the following discussion contains unavoidable generalities in many instances. However, sufficient references are made to other impact studies within (e.g., USGS/State Land's FEIS[2] on the Decker Mines, Big

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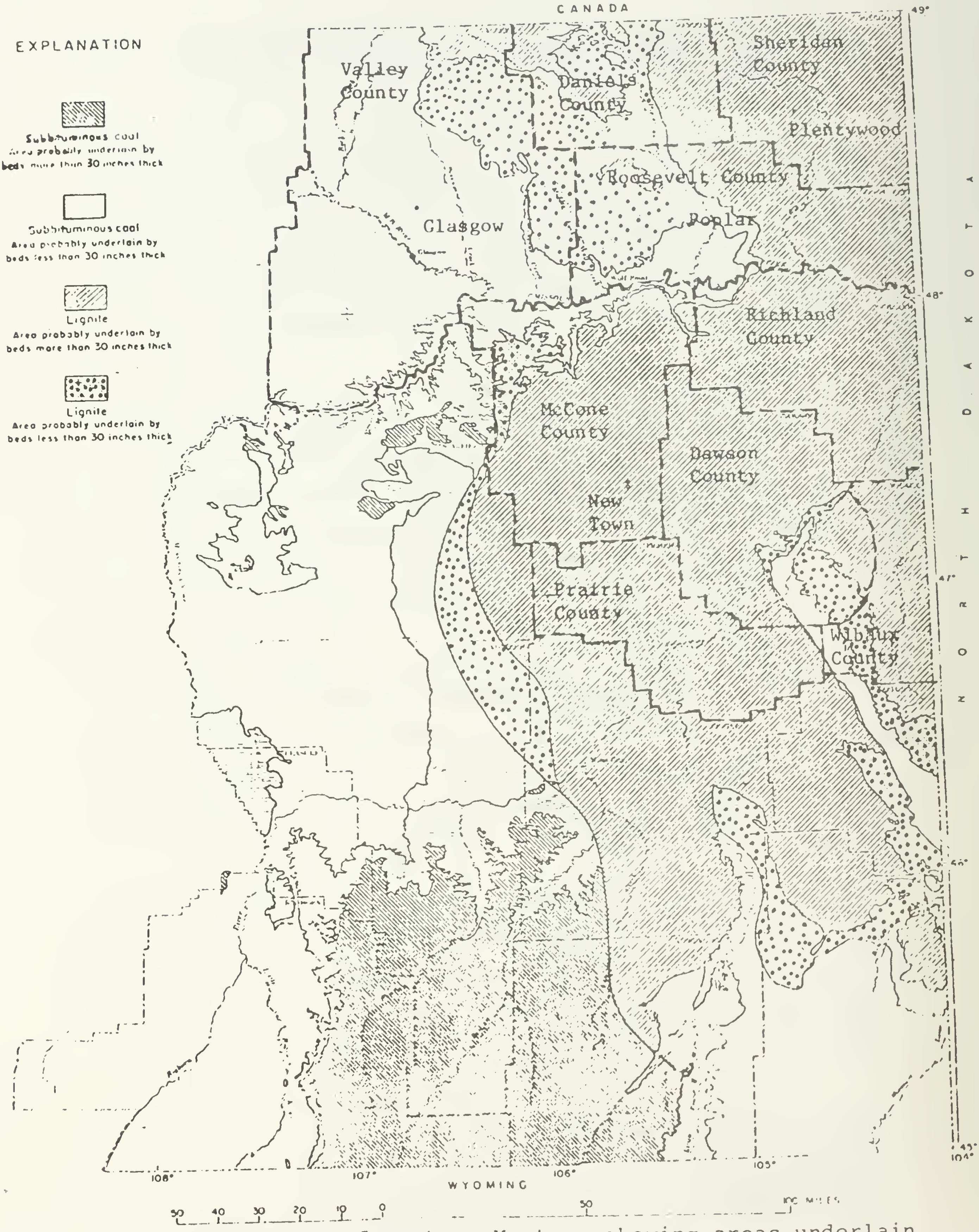
[1] Assumes 1740 tons-acre ft. and 13.86 ft. depth, with 90% recovery (i.e., 12.47 ft. extractable depth).

[2] Final Environmental Impact Statement



Map of eastern Montana showing areas underlain by coal-bearing rocks.

Figure E-3.1.1.

Horn County) and outside of Montana that, if pursued, will provide the reader with additional information to assess such a proposed development if it were actually initiated. At that time one should be adequately prepared to handle a formal environmental impact statement released for public review.

E-3.1.2 Physical

A. Atmospheric

1. Climate

Given the scale of the proposed gasification facility, no significant adverse alteration of temperature or humidity regimes (presently) existing in a five-mile radius of plant operations are expected. Some minor microclimatic influences will occur at the immediate site as the result of heat and/or moisture emissions from such operational components as evaporation/ash or water supply surge ponds, heat exchangers, scrubbed fine gases or cloud/ice formation downwind of the wet cooling towers (if used) on cold mornings. The general area's continental-steppe type climate with its limited precipitation events and high moisture deficit should largely mitigate even these site-specific impacts. However, improper complex layout could result in the icing-up of the existing aircraft runway, or possibly interfere with non-instrumented aircraft traffic due to reduced visibility during the "fog" episodes. The Western Gasification Company's (WESCO) 1985 level of operations (one billion standard cubic feet per day) is predicted to produce about 30,000 tons per year of carbon dioxide which is not expected to adversely effect the area's climate (U.S. Department of the Interior--USDI, WESCO); thus, impacts arising from the proposed GAFB facility via some "greenhouse effect" should be negligible.

It is highly unlikely that coal stripping activities would significantly degrade the baseline air quality (e.g., via total suspended particulate levels[3]) to the degree of changing baseline weather patterns.

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[3] That fraction of particulate matter in a given volume of air that remains in suspension sufficiently long to be trapped by high-volume type air quality samplers.

2. Air Quality

a) Mine Site

The major sources of air pollution during the construction phase would be from diesel-powered, heavy earth-moving equipment emissions, fugitive dust[4] and right-of-way/land clearance burning activities; small amounts of gasoline vehicle emissions would occur. The cumulative impact would be measurable but be of such a nature (over space and time) that would not constitute a significant, long-term impact on baseline air quality.

During the operational phase the major sources of air pollution would be from diesel equipment (e.g., hauling trucks, railroad engines), fugitive dust from mine operations, and smoke from occasional coal seam or spoil-bank fires.

Using data contained in the coal gasification EIS's for the WESCO and El Paso (USDI) syngas projects, rough order of magnitude emission estimates can be prepared for the diesel-run operations, as shown in Table E-3.1.1.

The contaminants should be released at a sufficiently low rate and be dispersed over a sufficiently large area that adverse impacts on the ambient (baseline) air quality should be limited to that space immediately adjacent to haulage paths (road/rail right-of-ways) and be largely intermittent in frequency.

Unit train coal transport (100-ton hopper cars, 100 cars per train) impacts during runs to the Lurgi/ammonia plant are estimated in Table E-3.1.2. As is the case for in-mine haulage from mine mouth to plant, the impacts will be minor.

Assuming a presence of 750 light-duty personal and company vehicles conforming to EPA 1980 vehicle-type and percent composition projections (WESCO, p. 3-3), wherein each vehicle averages 50 road miles per day, then an approximate overall emissions loading resulting from their use can be calculated. Table E-3.1.3 shows the projected impact of such operations.

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[4] Dust particles entrained in air currents and moved in an uncontrolled manner from a non-point emission source.

Table E-3.1.1--Expected Haul Vehicle Emissions From The Mining Operations Using a Truck/Railroad Haulage System[a]

Contaminant	Emissions (Pounds Per Day)	
	Minimum[b]	Average[c]
Total Particulates	4.4	38.6
Sulfur Dioxide (SO_2)	9.2	84.0
Hydrocarbons (HC)	12.6	110.2
Nitrogen Oxides (NO_x)	126.0	1104.8
Aldehydes (HCHO)	1.0	8.9
Organic Acids	1.0	8.9
Carbon Monoxide (CO)	85.1	670.7

a) With railroad at peak operation, the total combined truck and rail engine fuel consumption is reduced to 60% of the levels required for truck-only transport. In-mine coal transport via conveyor systems (assuming < 2 mile haul distance) could probably cut the above emissions in half.

b) Scaled down to meet the needs calculated for the coal gasification plant at GAFB using WESCO/El Paso type data.

c) Estimated from northwest-type coal operation data in Table 1-25, p. 1-61 in Energy Alternatives; taken to be the lowest emission levels that could realistically be expected from such an operation. Estimated from H. Shaw and E.M. Magee, Evaluation of ... Lurgi Processes, July 1974.

Source(s): Adopted from Table 3-1, p. 3-3 in WESCO EIS and Table 1-25 p. 1-61 in Energy Alternatives.

Table E-3.1.2--Estimated Air Pollutant Residuals For Coal Transportation By Unit Train[a]

Contaminant	Emissions (Tons Per 12.5 Rail-Miles Per Year)
Total Particulates	2467.2
Nitrogen Oxides (NO_x)	278.0
Sulfur Oxides (SO_x)	241.5
Hydrocarbons (HC)	185.3
Carbon Monoxide (CO)	260.2
Aldehydes (HCHO)	40.8

a) Unit train (100 cars) each car hauling up to 100 tons of northwestern coal, e.g., 6928 Btu/lb. high heating value (HHV), run-of-mine coal delivered at a rate to satisfy the 22,425 tpd plant requirements.

Source: Energy Alternatives, Table 1-56, p. 1-127.

Table E-3.1.3--Projected Vehicle Emissions Arising From Personal or Light-Duty (Company) Mine Vehicles

Contaminant	Emissions (Lbs. Per Day)[a]
Carbon Monoxide (CO)	2011.5
Hydrocarbons (HC)	267.8
Nitrogen Oxides (NO_x)	284.0
Total Particulates	53.6
Sulfur Dioxide (SO_2)	18.7

a) Calculated by the following factors: 750/1825, 50/100 and 2000/330 (WESCO value for a given containment); mine is assumed to operate at least 345 days per year.

Source: Adopted from the WESCO EIS, Table 3-2, p. 3-4.

The pollutants should be greatly diluted by air movements, thus causing no significant adverse effect on the overall area's vegetation or fauna. However, increased traffic could cause elevated heavy metal levels in road-side plant and soil materials (Lagerwerff and Specht 1970); nearby grazing stock should be fenced from road right-of-way areas to avoid poisioning incidents.

Sources of fugitive dust include coal stripping/loading/haulage activities, reclamation operations (e.g., re-contour grading) and previously graded-seeded reclamation plots. Impacts upon local air quality will be intermittent in nature and largely restricted to the area immediately surrounding the emission source. Detailed dust abatement procedures can be determined once the background (natural) vs. "best available" dust emission estimates are evaluated.

During a mine operation portions of the fractured coal can become mixed into the overburden materials. If this coal were to spontaneously ignite, the resulting fire would temporarily contribute to the local level of air-borne pollutants. However, it is very difficult to assess the intensity or frequency of such an impact on ambient air quality. It is thus assumed that such fires will be smothered out (with additional overburden) before they become a noticeable problem.

b) Gasification Plant

The burning of coal fines for process heat and steam production, plus the gasification of coal in the Lurgi vessels, releases numerous inorganic contaminants which must be controlled if the operation is to be environmentally compatible by law. An overview of possible methods for handling the gaseous stream pollutants is given in Table E-3.1.4.

In addition to these continuous emissions, atmospheric emissions will occur at various intervals from the flare-off system as shown in Table E-3.1.5. The composition of the incinerated product flow would be largely CO_2, water vapor, and varying amounts of SO_x, NO_x, and inorganic particulate matter (including trace elements). The rapid release of SO_2 during total emergency flare-off might cause ambient SO_2 levels to approach, if not exceed, the federal three hour secondary standard (0.5 ppm). This would cause discomfort to plant personnel in the area, especially under inversion-type atmospheric conditions.

The exact engineering design (e.g., stack height/diameter) and numbers (gas exit velocities/temperatures, etc.) of a plant for GAFB is not known which precludes the presentation of estimated individual stack or flare pollutant emission rates. The unavailability of these critical parameters disallows dispersion modeling/ground-level pollutant concentration calculations beyond the preliminary commentary by Brelsford, et al. (FEA I, pp. 114-123). However, comparison of the above estimates with those for Colstrip (DNRC DEIS, Table 11-1, pp. 637) results in a somewhat disconcerting feeling if the Lurgi plant is to be sited adjacent to potentially PSD I air quality type land (the Fort Peck Indian Reservation). Even though topographic-meteorological differences between Colstrip and Glasgow disallow direct comparison and interpretation of emission data for a given parameter, the magnitude of the SO_2 and particulate values (for the two operations) and existence of present or potential PSD I air sheds adjacent to each area does raise the question of environmentally compatible siting of such a Lurgi facility at the base. Such a concern can be documented by review of in-state press articles on the Colstrip/Northern Cheyenne Indian Reservation issue (Montana Standard, Butte, June 13, 1978, p. 1; June 16, 1978; p. 17; August 10, 1978, p. 5) and by review of the Bonneville Power Administration, et al, Draft EIS for Colstrip (BPA 1978). Clearly, the present engineering design and lack of plume dispersion modeling for GAFB as performed at Colstrip (Heinback et al. 19), or intensive air quality baseline monitoring as associated with the

Saskatchewan Power Plant assessment project (Gelhaus *et al*. 1977) would not be sufficient to certify the plant pursuant to the Montana Major Facility Siting Act (Title 70, Chapter 8, RCM 1947, as revised and amended).

Finally, it should be noted that the values presented in Table E-3.1.4 are based on assumptions as footnoted in that table. Subtle modifications of sophisticated SO_2 scrubbing (or particulate electrostatic precipitation) technologies and/or utilization of solvent-refined coal procedures could reduce SO_x emissions considerably from the auxiliary steam-electric plant (in particular). Also, it seems probable that NO_x, NH_3, HCN, or cyanate emissions would be further increased (over the Table E-3.1.4 levels) if process wastewater is incinerated rather than treated at the bio-oxidation water treatment facility (as proposed below).

The plant will be designed so as to emit no visible smoke plumes via removal of most particulate matter prior to venting the off-gases. However, fine particles escaping the electrostatic precipitators and/or sulfurous acid molecules that have escaped scrubbing may cause some scattering of light. This would be a function of atmospheric conditions and position of the observer relative to the plume (DNRC EIS, Volume 3B, pp. 681-682). If clear air and an unrestricted view are treasured locally as an aesthetic resource, their value could be reduced (on an intermittent basis) once the plant becomes operational.

3. Noise

a) Mine and Plant Construction--An Overview

It is predicted that the noise impact characteristics (quality and intensity) and frequency will be greatest during the construction phase of project development. Sources of this noise will include earth-moving equipment, the erection and/or fabrication of physical facilities, increased traffic from construction material delivery, and peak-hour personnel movements to and from the given site. The impact should be limited to tolerable levels (measured at the then-delineated property

Table E-3.1.4--Pollutant Handling and Estimated Emission Rates for the Lurgi/Ammonia Plant Operations

Contaminant	Handling/Mitigation Process(es)	Emission Rate (lbs/hr) Average[a]	Emission Rate (lbs/hr) BACT[b]
Sulfur Dioxide	Cause plant conversion to elemental sulfur using high H_2S streams; Stretford-Holmes plant for dilute sulfur streams.	413.8	144.6
Nitrogen Oxides	Regulation of air:fuel ratios; proper boiler design.	1890.8	1118.2
Hydrocarbons	Cryogenic Scrubbing	562.3	25.8
Particulates	Electrostatic Precipitators	51.8	11.7
Carbonyl Sulfide	Hydrolyzed in the Benfield acid gas removal step to H_2S, then treated as above.	4.3	------[c]
Fluoride(ine) - Gaseous & Particulate Forms	Electrostatic Precipitators/ Water Spray/Quenching	8×10^{-4}	------[c]
Mercury	Electrostatic Precipitators/ Water Spray/Quenching	2.75×10^{-2}	-------[c]
Ammonia	Electrostatic Precipitators/ Water Spray/Quenching	0.78[d]	-------[c]
Product Gases	Proper Storage/Transfer Designs	1.68[d]	-------[c]
Benzo(a)-pyrene	Proper boiler design	2.7×10^{-3}[e]	-------[c]

a) Adjusted for differences between WESCO Navajo-type coal and Montana Circle West/Burlington Northern-type coal; plant assumed to be operating at 100% capacity.

b) Adaptation of coefficients (i.e., per x 10^{12} Btu input) from Tables 1-46, and 1-47 in Energy Alternatives with the discussion on Best Available Control Technologies (BACT) given in Control of Emissions from Lurgi Coal Gasification Plants, U. S. EPA - 450/2-28-012, March 1978.

c) Data not available to make this calculation.

d) Calculated using data presented in H. Shaw and E. M. Magee, Evaluation of Pollution Control in Fossil Fuel Conversion Processes: Lurgi; EPA-650/2-74-009-C, July 1974, p. 33.

e) S. Miller, Environmental Impacts...Coal Development, OWRC, Washington, D. C., 1974, p. 94; assumes conventional dry or wet furnace; projected value increases by an order of magnitude if a cyclone-fired furnace is utilized.

Table E-3.1.5--Emission Characterizations of the Lurgi Flare-Off Component

Type of Occurrence	Frequency	Duration (Hrs.)
Normal Startup/Shutdown Related to Maintenance	Twice a Year	306
Initial Start up	2-3 Days Per Month for the First 6 Months	Variable (36-48, Initially)
Emergency Flare-off	As needed	1/2 to 1 at 100 Percent Production Level, Followed by 3-6 at 5-10 Percent of Total Production Rates

Source: WESCO, EIS, pp. 3-4 and 3-5.

boundary) by proper scheduling of activities and by proper maintenance and operation of equipment. However, some annoyance will occur to those working around the machinery unless appropriate hearing standards are abided by (Cheremisinoff 1977).

b) Mine Operation

Except for the coal and overburden loading/hauling operations, there most likely would be only one activity in progress at a given time at a specified location. The different activities would be arranged so that the noise level produced at one location should have only a minor (noise) influence at another site. In the work areas of WESCO's Navajo Coal Mine (with approximately 10.4 million tons extracted per year), Battelle-Columbus Laboratories' noise survey documented sound pressure levels varying from 68 to 82 decibel average (dBA) at distances of 50 to 150 feet from the source. "These levels are well below those set as limits for employee exposure by Coal Mine Safety and Health Act Standards, but are sufficiently high to interfere with voice communications," (WESCO EIS, pp. 3-19). Distances at which 250 ton-capacity haul-truck noise levels become inaudible ranges from 1/3 to 1 mile depending upon wind conditions. However, their noise emission levels would be distracting or annoying to personnel working nearby, especially if they were not adequately protected. Blasting would occur once or twice during the day shift (only) and be of impulse-type noise classification.

c) Gasification Plant Operation

In Battelle-Columbus Laboratories' study of the WESCO unit number one (Battelle-Columbus Laboratories 1977), predictive computations revealed battery-limit noise levels ranging from 58 to 68 dBA with most being below 63 dBA (Ibid); sound frequencies ranged from 125 to 1000 hertz (Hz). Because the maximum equivalent noise level (L_e) allowed by EPA for farm or generally unpopulated land areas is 70 dBA, it is unlikely that noise will be a problem at the GAFB facility unless the base is significantly repopulated. If this becomes the case, then the L_e must be reduced to about 50 dBA, i.e., to levels ordinarily observed in an urban-industrial setting (Cheremisinoff, Figure 4-9, p. 49). It is doubtful that any noise will be sensed at distances greater than 315 miles from the facility even under the "worst case" meteorological conditions. This presumption is based on a Battelle calculation that implied that the 288 mscfd[5] WESCO operation would be inaudible at distances greater than six miles and an implication of an objectionable noise level boundary lying within two miles of the 288 mscfd El Paso gasification facility (El Paso EIA, pp. 3-20, 3-21).

Researchers of the Occupational Safety and Health Administration (OSHA) have found that exposure in excess of eight hours per day to sound pressure levels of 90 dBA or greater can produce permanent hearing loss in unprotected personnel. Even well-maintained large fans, fluid-pumping systems, and coal processing areas can generate noise levels in excess of 83 dBA (USDI, Four Corners Power Plant/Navajo Mine DEIS, p. 307); exposure times must, therefore, be carefully monitored, or personnel must be isolated from the noise source if hearing is to be protected. Detailed sound surveys, under typical operating conditions, must be conducted at the completed plant so as to gauge the overall, cumulative impact of this factor on worker health and safety.

B. Water Impacts

1. Quantity-Surface Waters

A 1970 estimate of water withdrawal activities from the Missouri River sub-basin is presented in Table E-3.1.6. Using an estimated flow-through rate of 6.92 million acre feet/year measured at the Fort Peck Reservoir (FEA, Vol. I, p. 152), the above activities withdraw 8.70 percent of the total passed volume. An additional 11,500 acre feet per year usage by the proposed mine/gasification facility would increase this total usage to about 8.85 percent. Thus, even assuming a doubling of in-state usage of the available water supply (and after adjustments have been made for yearly and seasonal variations) for irrigation or municipal consumption, there should be sufficient water remaining to operate the proposed facility. However, increased agricultural usage, expanded thermal power generation downstream, or Montana regulations that give agricultural water needs priority over those for industry, could severely deplete the supply during low-flow (late fall/early winter) periods.

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[5] Million standard cubic feet per day

Table E-3.1.6--Estimated 1970 Usage Rates by Component or Sector of Upper Missouri River Sub-Basin Water

Component or Sector	Withdrawal Rate (Acre-Ft/Year)
Hydropower, Irrigation, Navigation	326,800
Reservoir Evaporation Losses	152,800
Non-Irrigative Agricultural Uses	108,400
Municipal Uses	14,000
	602,000

Source: Federal Energy Administration(FEA) I, p. 158.

Furthermore, assuming that the water is physically present for use throughout the plant's lifetime, the water must also be legally available for gasification-related purposes. Past studies of water use in Valley County reveal that the volume of claimed water rights is considerably greater than the flow rate of the main stem of the Missouri River (FEA I, p. 163). Consequently, rigorous ajudication proceedings would probably be necessary to establish gasification needs as a decreed beneficial water use under Montana's Water Resources Act (Section 89-101.1, et seq., RCM 1947) and that this volume would not interfere with valid prior appropriations under the Montana Water Use Act, Section 89-865, et seq. Finally, an uncertain amount of water may be legally withdrawn by both federal agencies (via rights acquired through construction of the Fort Peck Dam) and by the Indian reservations bordering the Missouri River (as acquired by the Winters vs. U.S. Supreme Court Decision) (FEA I, pp. 163-4).

With regard to out-of-state water rights, priority of appropriation is still the guiding principle. There is no indication that state courts have been prone to give preference to their residents who are sued by claimants of rights to water use in other states (Ibid). However, since there is no interstate compact applying to water contained in the Upper Missouri subbasin, this "first-in-right/first-in-use" idea is not established in federal law. In that case, Congress would resolve the conflict by allowing the Department of the Interior to supercede state law and allocate the water according to best/beneficial use.

2. Quantity-Ground Waters

Although wells reaching the Flaxville gravel aquifer are known to yield up to 100 gallons per minute (gpm) within the County, its properties near the base are not accurately known (FEA I, p. 149); however, values one-tenth of this maximum are commonly reported (Patton 1978). The deeper Judith River artesian aquifer commonly yields five to 40 gpm with a known maximum of 420 gpm (FEA I, Table IV-1, p. IV-9). Despite these extremes in well delivery capacity, it is difficult to imagine much more than two percent of the coal gasification plant water requirements being met by subsurface water sources. Thus, in the absence of extensive hydrogeological analysis of the base and adjacent environments, it is recommended that such ground waters be utilized only under emergency situations so as to prevent the possible occurrence of irreversible alteration in groundwater characteristics.

C. Water Quality

1. Overview

The diversion of such a small volume of surface water (see Table E-3.1.6 and associated discussion) for use in the mine/plant operations should have a negligible impact on natural riverine temperature fluctuations. Probable variations from the expected range should be within 1°F of expected levels. Furthermore, the construction of the proposed Fort Peck re-regulation dam below the existing structure would probably mask any effects produced by the energy facility withdrawal (Corps of Engineers 1978). If a surface diversion pond (e.g., Ranney-type collection system) is constructed off the main flow pattern for the purpose of either mine and/or Lurgi water supply, the removal of clear (largely sediment-free) water will induce a slight increase in suspended solids loading immediately downstream of the reservoir via river (or stream bottom) aggradation. If such a diversion is not implemented, the dissolved/suspended materials removed at the Lurgi facility's water treatment plant would have to either be stored in adjacent evaporation/holding ponds or mixed with other plant solid wastes prior to ultimate disposal. Finally, the water withdrawal could slightly increase the salt concentrations of the downstream waters during low flow periods when a sizeable portion of the river's discharge consists of return flows from irrigation runoff. A quantitative estimate of the potential impacts (e.g., reduced crop yields, soil structural changes) arising from elevated salinity levels cannot be quantified at present. No significant changes in the Missouri River's naturally ranging levels of dissolved oxygen, nutrients (e.g., nitrate, sulfate, and phosphate), heavy metal concentrations, or background radioactivity levels are expected to result from the diversion process. If the rate of general population increase in the mine area is so rapid that lagoons or septic tanks are implemented prior to construction of adequate regional sewage treatment facilities, there is a possible problem of elevated levels of fecal coliform and other enteric microbes, plant/algae nutrients, detergents and other organics (of varying degrees of biodegradability), and possible traces of heavy metals and biocides (e.g., herbicides and pesticides).

2. Mine-Specific Impacts

An estimate of mine-induced effluent levels (assuming uncontrolled release) is presented in Table E-3.1.7. Unfortunately, the impact of this contribution of nutrients, trace elements, BOD/COD, radioactivity, etc., into surface waters (e.g., Nelson Creek) from surface erosion sources, or groundwater contamination resulting from coal storage/spoil piles (or gasification ash leachates) that infiltrate into a local (particular) aquifer,cannot be quantified at this time. Such concern could be mitigated by implementing a surface station/test well monitoring system to perform water quality observations through the baseline, operational, and post-operational phases of the project (Berndt 1975). Several pertinent analyses of such impacts and proposed mitigating measures can be found in the Big Sky Mine environmental impact statement (USGS and Department of State Lands 1978).

3. Plant Effluents

The wastewater effluent discharge from the Lurgi facility is largely derived from a combination of sanitary/domestic sewage, raw water/recycle water treatment streams, gasification processes and reactions, and cooling tower blowdown. An estimated characterization of the wastewater effluent for the overall plant without sulfur controls operating and for sulfur recovery effluent streams are given in Tables E-3.1.8, E-3.1.9, and E-3.1.10, respectively. The accidental release of untreated effluents into adjacent surface waters (e.g., Porcupine Creek) could easily destroy the baseline biological communities existing there and adversely effect baseline (domestic/agricultural) water use activities for an indeterminant time period. Such an episode could extend its range as far as the Milk River, although dilution of the discharge to legally tolerable levels is likely.

D. Land Area (Process) Requirements and Estimated Solid Waste Levels

1. Mine

The estimated land area and amount of solid waste generated per process component of the overall operation is presented in Table E-3.1.11. Note that two land impact categories are included. The incremental land uses are needed for continuous mining/overburden soil storage/reclamation activities, while the fixed requirement is reserved for the permanent (i.e., non-salvageable) physical support facilities for the mine operation.

2. Lurgi Gasification/Ammonia Plant Phase

The estimated land area and solid waste generation rate for the gasification/ammonia plant is presented in Table E-3.1.12. According to the Dravo environmental assessment (Dravo 1976) the ash and slag will be disposed of by landfill in compliance with all pertinent federal and state regulations (Morrison-Maierle, Inc. 1976). Assumming that a 2405 tpd waste loading is equivalent (on a tonnage basis only) to the daily municipal refuse production of about 835,000 people (Kash 1975, p. 1-114), the proposed facility will generate about 53 percent of Montana's present daily solid waste production. For this reason it may be more sensible to plan the proposed operation at the mine-mouth so that the solid wastes can be effectively and economically disposed of in the nearby excavations. An alternative to mine-mouth disposal is to slowly fill a lined, 349-acre waste pond(s) to a depth of about 20 feet over the course of the conversion plant's lifetime (Miller 1974).

E-3.1.3 Geological/Physiographical Impacts

A. Overview

The construction and operation of the Lurgi facility and associated mine will probably cause the following general types of impacts as shown in Table E-3.1.13.

Possible consequences of significant geomorphological-related impacts include 1) the destruction of baseline surface drainage patterns with or without changes in long-term water quality; 2) creation of slope instabilities (especially for the case of improper reclamation) resulting

Table E-3.1.7--Estimated Residuals for Mine Operation by Process Component (Controlled and Uncontrolled Scenarios)

Component	Uncontrolled Rate	Controlled Rate[a]
Soil/surface disturbances resulting from in-mine haulage by diesel truck. Beneficiation via coal cleaning and washing.	2196.5 tpd[b]	0
Acids[c]	1.1 - 17.2 tpd	0
Total Dissolved Solids[c]	10.4 - 16.0 tpd	0
Suspended Solids[c]	20.0 -236.6 tpd	0
Waste Wash Water[d]	3.72×10^7 gpd	-
Reclamation-suspended solids from runoff (assume 5-year reclamation period).	7.62 tpy - acre[e]	∼ 0

Sources:

a) Assumes collection of the pollutants via catchment ditches, storm runoff drains, etc., and transfer to impervious (lined) settling or evapo-oxidation ponds where the chemistry of the effluent may be adjusted to immobilize (e.g., via precipitation) or eliminate (via oxidation in inert substances) the potential water pollutants. The processed supernatant would be recycled to in-mine uses, e.g., coal beneficiation, road dust suppression, etc.

b) Calculated from data in Table 1-25, p. 61 in Energy Alternatives; assumed to be measured as suspended solids.

c) Calculated from the Northwestern coal mining scenario, Table 1-27, pp. 1-65, 1-66, in Energy Alternatives.

d) Assumes 1700 gpt (Energy Alternatives, pp. 1-67) input with 97.5 percent pass-through in processing 22,425 tpd coal; water source derived from pit sump pumpage.

e) Assumes 2.54 tpy-acre suspended solids per inch of runoff; assumes runoff of 3 inches per year at mine site.

Table E-3.1.8--Estimated Composition of the Wastewater Effluent from a Lurgi Plant Without Sulfur Controls

Parameter	Before Treatment[a]	After Treatment[b] (in mg/ℓ)	Lb/Day Input[c]
BOD_5	1100	$\leq$ 30	326.6
COD	3150	$\leq$ 60	935.2
Ammonia (As N)	350	$\leq$ 270	104.0
Phenols	80	$\leq$ 0.001	23.8
Fatty Acids	2250	$\leq$ 20	668.0
Oil and Grease	40	$\leq$ 10	11.9
Total Dissolved Solids	3750	$\leq$ 200	1113.4
Total Suspended Solids	100	$\leq$ 10	29.7
Cyanide Ion	0.1	∿ 0	0.03
Thiocyanate Ion	20	∿ 0	5.9
Sulfide Ion	1400 (Maximum)	1.4	42.5
Sulfates	30	$\leq$ 10	8.9
pH Range	___	6.6 - 8.6	___

Sources: a) Taken from base plant values in Table 6.7, pp. 6-11 in U.S. EPA Control of Emissions from Lurgi Coal Gasification Plants, EPA-450/2-78-012, March 1978.

b) At point of exit from the water treatment process; although the effluent could conceivably be clean enough to be disposed of via a municipal sewage system, it probably will be recycled into plant operations.

c) Scaled down from expected Lurgi output from the 250 American Natural Gas's proposed plant near Beulah, North Dakota; assumes negligible influences arising from the approximately 4 percent difference in run-of-mine (ROM), HHV coal feedstock.

Table E-3.1.9--Approximate Composition of the Liquid Waste Stream from the Stretford Process Unit (i.e., Sulfur Controls Applied)

Component	Weight (Percent)
Sodium Carbonate	0.47
Sodium Anthraquinone Disulfonate	0.07
Sodium Meta-Vanadate	0.03
Sodium Citrate	0.03
Sodium Thiosulfate	0.60
Sodium Thiocyanide	0.60
Water	98.20
	100.00

Source: U.S. EPA, Control of Emissions from Lurgi Gasification Plants, Table 6.8, pp. 6-12

Table E-3.1.10--Estimated Composition of the SNG and Ammonia Feedstock Streams

	Ammonia Synthesis Stream		SNG Synthesis Stream	
Component	lbmole/hr	Mole %	lbmole/hr	Mole %
CO_2	6606.1	39.39	20996.7	35.97
H_2S	45.3	0.27	166.4	0.29
C_2H_4	67.9	0.40	249.7	0.43
CO	786.0	4.69	6164.1	10.56
H_2	7480.4	44.59	24208.6	41.48
CH_4	1641.2	9.78	6030.1	10.33
C_2H_6	102.7	0.61	377.2	0.65
N_2	45.3	0.27	166.4	0.29
Total Dry	16774.9	100.00	58359.2	100.00
H_2O	23.0		80.0	

Source: Dravo Corporation, Appendix C (American Lurgi Corporation), p. 18.

Table E-3.1.11--An Overview of the Estimated Area Requirements and Solid Wastes Generated by the Proposed Mine When Operated Under Pollution Control Conditions

Component/Phase	Solid Wastes (tpy)	Land Requirements Fixed or Initial (Acres)	Incremental (Acres/Yr)
Coal Stripping/ Reclamation	75993.0[a)]	≤ 10	355.4[c)]
In-Mine Coal Transport			
Diesel Truck	Not Applicable[e)]	Included in Above Figure[b)]	31.5[d)]
Mine-Rail (Diesel)	Not Applicable[e)]	≤ 10	6 per mile[f)]
Electrical Conveyor	Not Applicable[e)]	≤ 2	3.6 per mile[f)]
Coal Breaking and Sizing	356[g)]	103.8[g)]	--
Coal Cleaning and Washing	13533[g)]	55[h)]	--
Coal Loading and Transport	Not Applicable[e)]	40[h)] Plus 6 per Mile to Lurgi Plant	--

a) Taken from Energy Alternatives (EA), Table 1-17, pp. 1-48 to 1-49; assumes a 5-year reclamation period.

b) Allocated area for equipment storage, maintenance/repair shops, office, laboratory, etc.

c) Assumes coal requirement of 22,425 tpd for 345 days per year and 21,698 extractable tons per acre at the hypothetical mine site.

d) Taken from Table 1-25, pp. 1-60 to 1-62 in EA.

e) Treated as particulate air pollution ; see Tables E-3.1.1 and E-3.1.2 in the text.

f) Taken from pp. 1-126 in EA; assumes 55 feet and 30 feet right-of-way for railroad and conveyor systems, respectively.

g) Taken from Table 1-27, pp. 1-65 in EA.

h) Taken from pp. 1-67 in EA; (includes water treatment plant and settling pond).

in elevated levels of sheet and/or gully erosion processes; and 3) alteration of particular aquifer characteristics resulting in changes in the quality or quantity (as measured at a particular point) of its water.

Possible consequences of the soil-related impacts include the destruction of soil structure (with changes in permeability or measured water holding capacity) possibly leading to elevated erosion rates on steeper slopes. Secondary impacts would include possible changes in vegetative patterns, rangeland productivity, etc. The deposition of pollutants eminating from either plant- or mine-related operations (e.g., SO_x, NO_x, trace elements, silicaceous materials) could result in long-term changes in pH, nutrient availability/fertility, toxic substance accumulations, etc.

The extraction of particular materials for project support could possibly cause future need for more energy intensive and/or costly recovery technologies to extract that portion of the resource not utilized during the lifetime of the gasification project.

E-3.1.4 Biological Impact Assessment(s)

A. Overview of the Area

The area being proposed for development into a coal conversion/mine complex lies within the Midland Physiographic Province of Montana (Southard 1973); it is included as a portion of the northern extension of the continent's interior plains. The GAFB topography is flat to undulating, interspersed with coulees which feed into the creek drainage net flowing in a southerly direction until ultimate incorporation into the Missouri River. The land around the hypothetical mine site has a rougher topography, being characterized by deeply incised drainages and steep-sided buttes (Matson 1970). The overall area's continental-steppe type climate is arid to semi-arid with a wide range in annual temperature. The GAFB vicinity averages about 14.3 inches of precipitation a year, most of which occurs from April through September (FEA I, pp. 103). The mine site could receive up to 16 inches of precipitation per year with a pattern not unlike that of GAFB expected (Ross and Hunter 1976).

The major terrestrial plant communities are either grassland types with type distribution being largely determined by local differences in soil texture, or the scrub/benchlands or grass/sagebrush associations

Table E-3.1.12--Estimated Land Area Requirements and Solid Waste (Slag and Ash) Production Rates[a] for the Lurgi Gasification/Ammonia Plant Operation

Process Component	Solid Waste (Tons/Day)	Fixed Land Requirements (Acres)
Coal Storage and Preparation	2.3	200
Gasification and Ammonia Production		
Plant Facilities (Including Support-Related)	1267[b]	175[c]
Raw-Water Storage (Surge) Reservoir	--	55
Evaporation/Clear-Well/Slag Ponds	--	80
Ash/Scrubber Sludge Ponds	225d)	385e)

a) Taken from Table 1-46, p. 1-112 in Energy Alternatives and/or Table 14-2, p. 14-7 in the Council of Environmental Quality's MERES and the Evaluation of Energy Alternatives, Washington, D.C., May, 1975.

b) Dry tons, taken from Dravo, "Simplified Process Flow Diagram No. CPD-7024/SK-100L," 1976.

c) Assumes 150 acres for major activities and 25 acres for support facilities.

d) Scrubber sludge only.

e) Assumes 350 acres for ash holding and 35 acres for sludge holding.

Table E-3.1.13--Summary of the Anticipated Geological/Geographical Impacts Arising from the Mine/Plant Construction and Operation Activities

Component	Impact Type(s)	Magnitude/Scale
Geomorphology/Topography	Loss of surficial geological materials (i.e., overburden/interburden) and destruction of the local stratigraphic record.	Localized (limited) to areas undergoing construction, strip-mining, etc.
Soil Mantle	Compaction and/or Erosion Pollution Deposition	Severe, but site-specific. Diffuse and probably chronic over the lifetime of the project.
Non-Renewable Resources	Extraction of necessary materials to implement and maintain the project activities.	Diffuse, but site-specific.

Source: Adopted from the discussion contained in pages 699 through 703 in the State Department of Natural Resources and Conservation's Draft EIS, Volume 3B (Power Plant) for Colstrip 3 and 4, November 1974.

found predominantly in gullies and coulees. Streamside (riparian) vegetation is often dominated by a black-cottonwood or aspen overstory above a willow/rose shrub layer which in turn overlays a potentially lush groundcover of diverse grasses, herbs, and emergent hydrophytes (e.g., cattails and various rush species). Scrubpine, badland-grassland, and undifferentiated stream and lake bottomland habitats also are present but are much less extensive than the other plant community types.

The above plant communities support resident or seasonal populations of big game mammals, smaller furbearing or non-furbearing mammals, numerous upland game birds and waterfowl, raptors, and songbirds, plus reptiles and amphibians. A more complete discussion of habitat requirements and vegetative relationships can be found in the earlier GAFB production/siting study (FEA I, pp. 54-97).

E-3.1.5 Vegetation Impacts

A. Mine Construction and Operation Activities

The initial land clearing for the siting of the physical facilities (including water pipelines, high-voltage transmission lines, and associated right-of-way and access road areas) plus incremental losses caused by coal mining-related activities (including incompletely reclaimed mine areas) would remove a portion of the existing vegetation at least through the lifetime of the operation. Most of the land slated for clearance would probably be of grassland/shrub community type(s) similar to that observed around GAFB (Ross and Hunter 1976). Construction of a diversion/clarification reservoir and/or larger pumping stations adjacent to the Missouri River (or other applicable waterway) would destroy some small amount of floodplain or riparian plant communities. Because of the local but intense reduction in biomass production capability (at the particular impacted site) and the assumed approximate 10 percent energy transfer efficiency between trophic levels (McNaughton and Wolf 1973), small reductions in carrying capacity will produce larger reductions in the density of animal populations dependent upon it. Local extinction or forced migration of herbivores may occur; this would be especially true if the affected species' home ranges are smaller than that incrementally destroyed by the mine activities over time.

In terms of cattle production potential at the mine site, the loss of grazing land will be considerable; however, such loss probably will be economically less adverse than the corresponding beneficial market value of the mined coal. Given the mine land use data contained in Table E-3.1.11, an estimation of incremental impact consequent to lost cattle production can be prepared as shown in Table E-3.1.14. It should be noted that this rough order-of-magnitude cattle production loss was derived from extrapolating ECON, Incorporated's data gathered from silty to clayey, glaciated, climax range sites (ECON 1978) to similar grassland community types growing on texturally similar but nonglaciated soil types as found around the hypothetical mine area (Ross and Hunter, op cit.).

If these mining and reclamation rates are plausible and approximately constant, one can expect a rapid initial loss in cattle carrying capacity that reaches a plateau somewhere during the fifth year of operation; this elevated but nearly constant level will then exist throughout the duration of the operation. The land may be restored to the approximate level of original productivity about five years after cessation of stripping activities; however, clear assessment of ultimate impact intensity must await site-specific analysis.

The ultimate impact is dependent upon the potential of the applied reclamation procedures and how effectively they are implemented and managed (Doyle 1976 and Vories 1976). Because of the climatic factors controlling the function of the area's ecosystems, recovery from anthropogenic stresses (e.g., disruption of soil structure or soil profile inversion, possible long-term nutrient leaching from gasification plant acid precipitation, etc.) will be slower than for grassland ecosystems more favorably situated.

Presently, it is not possible to ascribe an overall index value derived from an environmental damage function (Ott 1978) to assess the cumulative potential impact arising from the given mining activities. This effort must wait until the permit area boundaries have been delineated and after detailed environmental baseline studies have been prepared.

B. Lurgi/Ammonia Facility

A review of the scientific literature reveals that little is known about the long-term effects resulting from such a facility's low (but probably legal) levels of gaseous and particulate emissions on the exposed vegetation or associated animal community (El Paso, p. 3-32).

Table E-3.1.14--Projected Losses in Cattle Production Arising From Strip-Mining Activities

Year of Operation	Cumulative Acres[a]	Cumulative Reclaimed Acres[b]	Animal Units/Month (AUM) Losses Year[c]
1	576.2	0	102
2	1010.6	0	165
3	1445.0	0	228
4	1879.4	0	290
5	2313.8	355.4	290
10	4485.8	2527.4	290
15	6657.8	4699.4	290
20	8829.8	6871.4	290
25	11001.8	9043.4	290
30	--	10781.0	40[d]

a) Assumes a fixed (permanent) loss of 220.8 acres for use as physical facilities (e.g., coal handling areas, maintenance shops, offices) and an incremental use of 355.4 acres per year associated with the stripping-phase of the operation (over a 25-year project duration).

b) Assumes a reclamation period of five years prior to restoration to pre-mining levels of land productivity.

c) Assumes the following categories of land disturbances and their respective carrying capacities: 1) for physical plant, 50% upland grassland type and 50% juniper grassland type, having 6.16 and 5.04 acres/AUM respectively; 2) for coal stripping, 55% upland grassland, 35% juniper grassland (with same respective carrying capacities as in (1) and 10% lowland, e.g., sedge meadow type having a 5.70/AUM range capacity. These figures have been derived by averaging ECON, Inc., field data gathered from relatively "healthy" sites within the intensive GAFB study area.

d) Assumes that the physical facilities are allowed to remain without salvage at the completion of mine operations; thus, the original 220.8 acres allocated for such activities will be permanently removed from production.

Thus, the scenario presented in Table E-3.1.15 is only an estimate of the overall magnitude and chronology of air pollution-related events that might follow from implementation of gasification/ammonia production activities.

It is predicted that acute response to the phytotoxic gaseous fumigation(s) will produce extensive foliar bleaching, necrosis and/or defoliation on particularly sensitive plant species within the first few years of operation (Dvorak, et al. 1977). Furthermore, severe climatic episodes (e.g., drought years) and/or grazing pressure stress could combine with the above anthropogenic impact in a manner that would eliminate the most sensitive species or subspecies, thus causing insidious changes in the local flora community.

The initial severe (acute) impacts would largely be followed by chronic effects resulting from prolonged or intermittent periods of low level fumigation during temperature inversions or from elevated overall trace element soil deposition rates (Dvorak, et al. pp. 115-118). It is possible that SO_x or SO_x/NO_x/trace element synergism effects may reduce productivity (i.e., biomass yields) via subtle changes in certain species' physiology without causing any significant visible pathology (Thomas 1956).

The acid precipitation fallout effects result from the oxidation of largely gaseous pollutants to their corresponding acids, e.g. sulfurous/sulfuric, nitric, hydroflouric, etc. The deposition rate (and consequent range of geographical impact) will be determined by a number of parameters including reactant concentrations, meteorological conditions, and other affective/cumulative pollutant sources (e.g., the proposed power plant to be sited near Coronach, Saskatchewan). Delineation of the supposed coal conversion plant "impact zone" (Table E-3.1.15) was cautiously extrapolated from nonferrous smelter and coal-fired power plant case studies from sites located in Montana (DNRC, pp. 726-752) and elsewhere. It is predicted that the Lurgi/ammonia plant's impact will originate at the battery limits (e.g., via cooling tower moisture-stack particulate reactions) and possibly extend 40 miles downwind of the operation unless superior control technology (i.e., greater than 95 percent pollutant capture efficiencies) is utilized. Given the fact that the northeasternmost boundary of the Charles M. Russell National Wildlife Range lies within the predicted "rainout" zone (consisting largely of grass/sagebrush communities), it is suggested that wide-spread additional air

Table E-3.1.15--Projected Chronology and Magnitude of the Terrestrial Biological Impacts Arising from Facility Operation[a]

Duration (Years)	Magnitude (Miles Radius from Facility)	Commentary
0-5	≤ 2	Acute Impacts
0-25	$2 \geq D \leq 5$	Chronic Impacts
0-25	$\sim 0 \geq D \leq 40$	Acid Precipitation/Toxic Particulate Fallout Impacts

a) Produced largely through the extrapolation of data, predictions, and discussion(s) found in the DNRC and Bonneville Power Administration, *et al*'s, environmental impact statements for Colstrip Units III and IV, (Colstrip, Montana), and the final EIS documents for the WESCO and El Paso coal gasification projects proposed for San Juan County, New Mexico.

quality monitoring data be acquired and dispersion modeling be implemented prior to serious consideration of siting such a conversion facility at GAFB.

As discussed in the process description, there will be no dumping of process effluents into any surface drainage or groundwater aquifer. However, accidental release of stored chemical wastes (e.g., trivalent arsenic, ammonium or cyanide ions, phenols, etc.) or consequences of normal activities (e.g., long-term erosion of compacted, silty soils) could create conditions unfavorable for flora biomass production. Such a reduction in carrying capacity could reduce the herbivores dependent upon it for existence. However, the ephemeral (flow) nature of the drainage courses immediately adjacent to the proposed GAFB site may largely mitigate this possibility, creating instead a waste handling or groundwater protection problem. Finally, although acid precipitation can seriously reduce the naturally-occurring pH value in aquatic habitats, it appears probable that the basic salt concentrations (ECON 1978) in the area's permanent, regional drainages are sufficiently great (FEA I, Tables 34-6, pp. 166-7, 169) to largely buffer or reduce this potentially adverse impact.

E-3.1.6 Wildlife Impacts

A. Overview

The expected impacts of the proposed mine and gasification developments involve direct loss of topographical (cover and forage) habitat, generating local, but possibly intense, adverse impact upon the various animal populations. Those members of the faunal community not eliminated or displaced by such a decrease in local carrying capacity will be more or less exposed to the air emissions released by the mine or coal conversion facility depending upon their location. Finally, the increased human population could affect the area's wildlife via increased hunting pressure or harassment via recreational pursuits. Quantification of this matter for the mine scenario must await site-specific analysis; Lurgi plant operations could moderately impact the area's game populations and may require State Department of Fish and Game intervention in certain areas for protection of certain game species (ECON 1978).

B. Mine Construction and Operation

About 221 acres of habitat would be lost to the physical facilities and the stripping operation would eliminate a maximum of 1958 acres (at a given point in time) during the mine's lifetime (Table E-3.1.14). The impact of such an action upon the resident and transient mammal populations is not well understood. The most obvious effect of land clearing would be the displacement, if not elimination, of those terrestrial species (e.g., diurnal ground squirrels, prairie dogs) exposed to the hazards of large-scale earthmoving activities. The largely undelineated mine site location and apparent unavailability of existing baseline herbivore density surveys disallows any reliable estimation of the magnitude of such losses. However, extrapolation from calculations performed on a gasification complex proposed for the southwestern United States indicates a 15 percent reduction in small mammal density within the general mine area (El Paso, p. 3-37). If the reclamation program restores all but the 221 acres in a manner that re-establishes a plant community that is at least equal in quality (in terms of production) and abundance (i.e., assuming no overgrazing) to the preliminary baseline conditions, the impacted fauna could eventually increase to within five percent of the pre-construction carrying capacity (WESCO, pp. 3-35). Finally, loss of riverine (e.g., marsh) habitat through the placing of pumping stations, a diversion reservoir, etc., could be significant to those species dependent upon such ecosystems. Such activities would be largely limited to several acres in scale with the displacement or elimination of animal species being intense and localized but probably not constituting a significant adverse impact on the region's biota.

The effects of noise on wildlife populations are not well documented although the operations could very well disrupt some aspects of behavior (e.g., intrapopulation auditory signals and predator-prey relationships) within 1/4 mile of the noise source (WESCO, pp. 3-36). Particularly mobile mammalian species living within this zone may thus shift their home range centers away from the sites of mining activity. If the displacement is sufficiently large, adjacent portions of a particular ecosystem type could be temporarily stressed prior to reaching population equilibration levels via competition and mortality. It should be noted that the intensity, and possibly the magnitude, of these population disruptions could be mitigated through the creation of new species' niches (e.g., associated with human habitation, weedy annual plant communities along roads, pipelines, railroad right-of-ways, revegetated soil banks, etc.). Thus, the overall impact will be localized and arranged sufficiently as not to constitute a severe problem to the general region.

The clearing of land for mine construction and operation could induce local destruction of galinaceous game bird habitat (e.g., sharptailed grouse breeding grounds) or reduce raptor populations via reduction in prey densities, loss of nesting areas, mortality arising from collisions with power transmission towers, etc. If the human impact is severe enough the latter bird type(s) might migrate from the area permanently since they tend to habitually nest only at particular sites year after year. Their general absence could be followed by a rapid growth of rodent or lagomorph (e.g., rabbit, hare) populations. If uncontrolled by other predators (e.g., coyotes, badgers) the herbivore species might exceed the local vegetation carrying capacity and/or interfere with successful reclamation efforts (WESCO, pp. 3-40). Finally, birds generally have a more rapid metabolism rate than do mammals; thus mine air emissions may have some long-term adverse impact on the exposed resident populations.

The mine's effect on resident reptile and amphibian population densities cannot be accurately quantified prior to the performance of baseline studies at the then-delineated mine site area. The incremental land clearing associated with coal stripping could destroy significant numbers of less mobile species, although the magnitude of this impact cannot be calculated at this time. It is assumed that the impacted species would eventually repopulate the reclaimed areas to near preconstruction levels if the proper habitats are present and are not yet at carrying capacity for a given species or life form.

Insect populations, especially pollinator types, could be adversely affected by particulate or gaseous emissions arising from mine activities (USGS/SL Big Sky Mine DEIS, p. III-18).

C. Lurgi Gasification/Ammonia Plant Impacts

Assumming that the facility activities will be largely confined within the base's perimeter, destruction (or at least short-term unfavorable modification) of wildlife habitat will be limited largely to the construction of 1) pipelines for water deliveries and gas transfer, and possible high-voltage electrical transmission lines, 2) unit train haulage from the mine (including reconstruction of the existing Glasgow to GAFB spurline), and 3) isolated physical facilities, e.g., pumping stations, access/maintenance roads, etc. It is predicted that such activities will induce diffuse but locally intense impacts, e.g., utility or railroad right-of-ways may constitute barriers to wide-ranging mammals such as the pronghorn antelope. The potential habitat impact can be adequately treated only on a site-specific basis after the detailed plot plan has been prepared.

The mammalian fauna existing within a several mile radius of the facility will be exposed to sulfur compounds (e.g., SO_2/SO_3, particulate sulfate, H_2S), nitrogen oxides, thio- and metallic carbonyls, plus minute quantities of heavy/transition metal and radioactive trace elements. Although the scope and degree of these impacts on the resident populations is presently highly speculative, the possibility exists that long-term, low-level (even if legal) exposure to such pollutants will manifest itself as time progresses well into the project's duration. Adverse reactions could range from acute pulmonary edema arising from intense episodes of fumigation by SO_2 (El Paso, pp. 3-34) to reduced immunochemical responses or unfavorable metabolic reactions resulting from elevated trace element burdens (DNRC, Vol. 3B, pp. 754-7). The elevated mortality and chronic disease rates would probably affect relatively small numbers of given species' populations; furthermore, the assignment of cause-effect relationships to such statistics is very difficult because of the possible number of interacting factors potentially involved in each suspected case.

The local disruption of the landscape also will adversely affect the local resident bird populations (and raptor species in particular) via habitat destruction and noise impacts (e.g., anomalous behavioral responses). Mortalities arising from improperly designed high-voltage lines (HVT) or collisions with unclearly marked HVT towers or coal conversion facility vent stacks also are possible but of unlikely biological significance. Amphibians and/or reptile species might be directly effected by gaseous/particulate emission intoxications or by trace element burdening acquired through the food chain. The present uncertainty regarding final engineering design, plant scale, and location disallows any quantified estimates of the above impact types. However, such concerns would be addressed in the applicant's environmental impact assessment if such a facility is proposed for the area.

As discussed in the overview, the various toxic materials (e.g., phenols/aromatics, cyanide ion, unionized ammonia, trace elements) could produce a presently undetermined but possibly adverse impact to the exposed fauna (i.e., water fowl, mammals) if accidentally released into the local groundwater(s) or suface drainage(s). Furthermore, neither the frequency nor consequences of evaporation/waste holding pond visitation by birds or land mammals for resting or drinking purposes can be evaluated. The extent of thses impacts must await accurate effluent characterization and concentration calculations followed by comparison of the latter values to those listed in EPA water quality criteria manuals for each pollutant.

D. Endangered Status, Undetermined, and Threatened Species

A yet-to- be published study by T.J. Watson, Jr. (1976) concludes that the designated plant species (Golden, et al. 1979) are largely limited to areas west of the Continental Divide. Given the data for northeastern Montana flora, and interpreted in the light of the past century's agricultural (grazing and cropping) impacts, it is cautiously assumed that the coal conversion/mine complex would have little, if any, adverse impact on such category of plant species. However, the scientific and regulatory literature (e.g., 41 Federal Register, 117: 24367, 1976) must be followed closely if potential scheduling delays arising from such litigation are to be avoided.

Several mammal and a number of bird species inhabiting or observed in northeastern Montana are listed as endangered or threatened species; in addition, a small group of bird species remain in an "undetermined status" position as shown in Table E-3.1.16.

The coal complex will be sited on lands that may easily include open plains or shortgrass prairie types of habitat. It then is possible that the project area will include blacktail prairie dog (Cynomys ludovicianus) colonies of sufficient size that can support resident populations of burrowing owls (Speotyto cunicularia) and/or blackfooted ferrets (Mustela nigripes). Due to the dependence of the ferret upon the prairie dog, it is of utmost importance to maintain the latter's habitat if the former

Table E-3.1.16--Endangered, Status-Undetermined, and Threatened Animal Species Present in Northeastern Montana[a]

Mammals		Status[b] Code	Birds		Status[b] Code
Common Name	Scientific Name		Common Name	Scientific Name	
Black-footed Ferret	*Mustela nigripes*	E	American Prarie Falcon	*Falco mexicanus*	T
Northern Swift Fox	*Vulpes velox*	E	American osprey (Fish Hawk)	*Pandion haliaetus*	U
			Burrowing owl	*Speotyto cunicularia*	U
			Ferruginous hawk	*Buteo regalis*	U
			Mountain plover	*Eupoda montana*	U
			Northern long-billed curlew	*Numenius americanus*	U
			Peregrine falcon	*Falco peregrinus*	E
			Whooping crane	*Grus americana*	E

a) Common names taken from FEA I (1975), Table 17, p. 82; zoological nomenclature taken from *Threatened Wildlife of the United States*, USDI, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Office of Endangered Species and International Activities, U.S. Government Printing Office, 1973 edition.

b) Explanation of status code: 1) endangered (E) pertains to those species in imminent danger of extinction (at least in part of their range) as of July 14, 1977 (*Federal Register 42* (135), July 14, 1977: 36420-36431); 2) threatened (T) refers to those species whose survival requires the mitigation of a variety of factors (e.g., habitat disturbance, or over-exploitation/hunting) but not necessarily in danger of extinction and 3) undetermined (U) status wherein population/habitat detail was inadequate to classify the particular species into the (T) or (E) categories as of July 1977.

is to survive. Prior to mine siting, joint surveys should be completed with the Department of Interior's South Dakota Cooperative Wildlife Research Unit to ensure that coal stripping activities do not jeopardize their ferret recovery program's effectiveness in Montana (USDI, Fish and Wildlife Service 1978a,b). This type of activity is particularly important as a recent Brookhaven study has concluded (via analysis of potential energy development locations vs. species range(s) geographical overlays) that conflicts between endangered species and potential energy projects could occur in Rosebud and/or Valley Counties in Montana (Brookhaven Institute 1978). Finally, diligent surveillance of the potential mine site area for the presence of the northern swift fox (Vulpes velox) and the northern rocky mountain wolf (Canis lupus irremotus) critical habitats should occur at least through the baseline monitoring phase of the project. Although the wolf is not expected to be present in the fauna of northeastern Montana (USDI, Threatened Wildlife...pp. 235-6 and Burt and Grossenhender 1976 1976), a female specimen has been killed near Glasgow (Montana Standard October 22, 1978). This rare occurrence should be carefully assessed in the design of impact mitigating measures (e.g., reclamation) for mine (and possibly for gasification plant) operations.

The mine/gasification project area contains habitat capable of supporting the ferruginous hawk (Buto regalis), the prairie falcon (Falco peregrinus), and possibly the northern long-billed curlew (Numenius americanus). These species, if present, would be more-or-less stressed by the increasing activity of the operating mine/gasification complex; the paucity of presently available biological data does not allow even a rough order estimate of the response of these populations to the project-associated activities.

Although no critical habitat appears to exist for whooping crane (Grus americana) in Montana, it is probable that they utilize a portion of the C. M. Russell Wildlife Range as a resting stop during their biannual migration to and from Canadian breeding (summer) grounds (Robbins, et al. 1966). Consideration for the well-being (e.g., disturbance-free submerged and sandbar maintenance) of this species must be included in planning activities if conflicts/scheduling delays analogous to those occurring near Wheatland, Wyoming (High Country News 1978 and the Montana Standard October 7, 1978) are to be avoided. The osprey and/or peregrine falcon may be affected 1) directly through conversion complex trace element emissions in a manner analogous to those predicted for the Harry Allen power plant in Utah (USDI, Endangered Species...1978c), and/or 2) indirectly through the increased probability of exposure to humans along the reservoir. This is an especially important factor in maintaining the peregrine falcon since if this bird is disturbed or displaced during resting periods (at traditional sites) it may not renest even in nearby areas (USDI, San Juan... FEIS ; P. 3-29). If either of these impact categories were to occur it is possible that plant/mine scheduling could be delayed until mitigative measures were developed and applied to satisfy existing federal requirements, e.g. the Endangered Species Act (P.L. 93-205, as amended), and associated Montana Department of Fish and Game regulations (Montana State Legislature, Environmental Quality Council 1978).

E-3.1.7 Health and Safety

The Lurgi/ammonia plant and coal mine will be constructed and operated to meet all federal, state, and local worker health and safety requirements. Protective equipment/systems in noisy, dusty, or otherwise hazardous areas or conditions should mitigate any adverse impact occurring in the overall coal conversion operation (Cohen 1978).

E-3.2--RAIL CAR REPAIR FACILITY AIR QUALITY IMPACT

Although the operational emission levels cannot be quantified because of present uncertainty in plant design, activity levels, etc., a qualitative impact assessment can be prepared. Table E-3.2.2 shows the anticipated intensity and scale of the facility's operation on present air quality. Noise will be the most obvious hazard, but ear plugs will protect the workers and no significant noise levels should extend beyond the base perimeter.

It is thus predicted that environmental impacts arising from facility operation and maintenance will be negligible, as measured at the base's perimeter. Intense air temperature inversions or gusty winds could produce local (i.e., base-restricted) and intermittent deterioration in baseline air quality. However, violation of pertinent standards remains unlikely.

Table E-3.2.2--Operation-Related Air Quality Impact Projections

Operational Component	Pollutants	Impact Magnitude/Importance[a]
Hot water boiler	Gaseous/particulate	1/1 to 2/2
Yard (e.g., switching, salvage)	Diesel emissions	1/2 to 2/2
Yard (e.g., switching, salvage)	Dust/non-engine particulates	1/1 to 2/1
Yard (e.g., switching, salvage)	Noise	2/3 to 2/5
Blacksmith shop	Metallic particulates	1/1 to 1/2
Blacksmith shop	Forge process heat	1/1 to 1/2
Blacksmith shop	Gaseous emissions	1/2 to 1/3
Blacksmith shop	Noise (in-plant)	1/4 to 1/6
Paint/stenciling shop	Paint particulates/vapors	1/1 to 1/2
Paint/stenciling shop	Solvents (cleaning)	1/1 to 1/2
Paint/stenciling shop	Noise (in-plant)	1/2 to 1/3
Truck (wheel components) repair	Steam hammer releases	1/4 to 1/7
Truck (wheel components) repair	Sandblasting (silicate, metallic) particulates	1/4 to 1/6
Truck (wheel components) repair	Burning/welding oxyacetylene fumes	1/2 to 1/4
Truck (wheel components) repair	Noise (in-plant)	1/4 to 1/7
Car body refurbishing	Noise (e.g., riveting guns)	1/4 to 1/5
Car body refurbishing	Burning/welding OA/arc fumes	1/2 to 1/3
Woodshop	Sawdust/particulates	1/1 to 1/2
Woodshop	Noise (in-plant)	1/2 to 1/4
Materials storage (warehouse)	Forklift (diesel) emissions	1/1 to 1/2
Materials storage (warehouse)	Volatile fumes	1/1 to 1/2
Materials storage (warehouse)	Noise (in-plant)	1/4
Personal and company light-duty vehicle operations	Noise	2/3
Personal and company light-duty vehicle operations	Particulate (including seasonal dust)/gaseous emissions	2/2 to 2/3

[a] Numerator and demoninator values range from 1 (i.e., negligible regardless of chosen timeframe) to 5 (i.e., "action threshold") to 10 (i.e., clear violation of pertinent federal, state, or local laws, regulations, etc.).

E-3.3--NOISE GENERATED BY LARGE-SCALE WIND MACHINES*

. . .The following analysis therefore aims at identifying the conditions under which windfarm noise will be most prominently louder than background noise and to relate past observations to probably worst cases. In the worst case analysis, three elements are to be considered: the sound power emitted by the wind machine itself; the sound power emitted by adjacent sources; and the sound intensity reaching a hearer from the combination.

A wind machine generates sound power in two modes. The first mode arises from displacement of the air as the blade momentarily separates it. In this mode the blade behaves as an aerodynamic monopole (Heller and Franken, 1971) and the emitted power varies as the fourth power of the blade speed through the air. The second mode arises from the interaction between the blade and the flow of air to produce unsteady forces. In this mode, the blade behaves as an aerodynamic dipole and the emitted power varies as the sixth power of the blade speed through the air. The support tower and other stationary elements of the wind machine also emit sound, the power of which varies with the sixth power of the windspeed.

The noise generated by an aerodynamic dipole is:

$$W = \frac{A\rho L^2 u^6 n}{c^3}$$

W = noise power, W

A = constant characterizing the geometry of the blade

ρ = density of air, $\mathrm{kg.m^{-3}}$

L = a characteristic length of the blade, m

u = airspeed relative to blade, $\mathrm{m.s^{-1}}$

c = speed of sound, $\mathrm{m.s^{-1}}$

n = number of blades

This may be rewritten in dimensionless form as

$$\frac{W}{2\rho u^3 L^2} = M^3$$

M = Mach number

---

* This text is quoted from Environmental Impact of Large Windpower Farms, Wallace E. Howell and C. J. Todd, 1978.

For any wind machine then, the noise will be emitted almost entirely from the fastest moving part, and noise from other parts may generally be neglected. For a horizontal-axis wind machine, this is the blade tips. For a vertical-axis machine it is the center portion of the blades. For any windspeed below cut-in or above cut-out, the relative airspeed is simply the windspeed. Considering first a horizontal-axis machine in operation, the relative airspeed at the blade tip may be obtained from the relationship

$$u^6 = [(r\,\Omega\,)^2 + V^2]^3$$

r = blade radius, m
Ω = blade rotating rate, rad.s^{-1}
V = windspeed

If we take the first two terms of the binomial expansion, we have

$$u^6 = (r\Omega)^6 \left[1 + 3 \quad \frac{V}{r\Omega} \quad ^2 \right]$$

A typical maximum value of $(V/r\Omega)$ is 20/120 so the maximum value of the second term is about 0.085. This amounts to about 0.3 dB difference in noise level between cut-in and cut-out windspeeds and can be neglected in comparison with other terms. However, as V increases, the geometrical factor A may change, increasing or decreasing according to the specifics of individual blade designs.

Thus for blade noise from horizontal-axis machine we may write

$$W \propto r^2\ (r\Omega)^6.$$

Since $(r\Omega)$ has a typical limiting value, the noise power of the blades as a whole increases with the square of their length, as also does the power output of the machine. Therefore, the blade noise power per kilowatt of machine capacity is invariant with machine scale size but depends sensitively on blade tip speed. The value of the geometrical factor remains to be determined experimentally for each machine, pitch setting, and windspeed. Thus, a scale-up in power rating from the 100KW of the Plum Brook machine to 3000 KW, the largest currently projected, implies an increase in blade noise of about 15 dB per machine.

To the blade noise one must add the noise power of the supporting structure which, being of dipole origin, increases with the sixth power of the windspeed. When the two components, blade noise and tower noise, are combined, it is obvious that the blade noise will be more prominent at the cut-in windspeed. Since tower noise is a familiar element from experience with radio towers, etc., and is known to be no problem, we may conclude that the largest projected wind machine operating at cut-in speed presents the worst case with respect to noise prominence. The next question is, how loud will this be in comparison with the background noise level?

Which brings us to the subject of noise emitted by adjacent sources. In the worst case, this means the noise generated by the wind in passing over the ground near the hearer. This noise,like that of the blade tip, varies with the sixth power of the windspeed and depends on the type of ground cover. Under typical conditions of attenuation, the noise generated near the hearer dominates that coming from more distant parts of the ground area.

Under these conditions, the machine noise will be most predominantly louder than the background noise when the machine is operating at its cut-in speed and when the hearer is close to the machine. Personal observations referred to in the literature have related to conditions generally less favorable than this one, ar at least no more favorable. Therefore, one is justified in the conclusion that no condition worse than those already found innocuous can occur in the immediate vicinity of a wind machine. The wide spacing of machines, combined with the natural attenuation occurring outdoors (Kurze and Beranek, 1971), assures that no condition will be found worse than that of a hearer near a single machine.

When it comes to noise beyond the perimeter of the windfarm, the dependence of noise propagation on the physical state of the atmosphere becomes the major factor. Under weather conditions that are usual when the wind is blowing hard enough for its noise to be considerable, the decrease of temperature upward causes sound waves to be refracted so that they curve upward away from the ground. The consequence is that loudness diminishes with distance from the noise source much more rapidly than it otherwise would, and a noise even as loud as thunder becomes inaudible at a distance of 2 or 3 kilometers if its source is at the ground. For noise sources elevated above the ground, the same is true if one measures the distance from where the sound ray grazes the ground tangentially.

Two atmospheric conditions are capable of extending the range of audibility. One is when shear is present near the ground. In the downshear direction, the air motion tends to refract the sound wave toward the ground and may overcome the upcurving refraction due to temperature lapse. Under some conditions the sound energy might then be trapped in a duct near the ground and would be attenuated more gradually as it spread sideways. The other condition, which might occur with light winds but practically never with strong ones, is temperature inversion; if pronounced enough, it also would confine the noise energy to a duct near the ground. The most usual instance of this condition is found over cool water on a still night when voices can often be heard at an unusually great distance.

The lower the frequency of a sound, the less it is attenuated in its passage through the atmosphere. Already at the boundary of the windfarm most of the high-frequency noise of the more distant machines - the hiss and swish of their blades - will have been absorbed, and only the lower-frequency component will escape the boundaries. Familiar instances of this phenomenon are the rumble of a distant train with none of the clatter and the low-pitched mutter of a city as heard from the top of a skyscraper.

Infrasound, air-pressure waves too low-pitched to be heard, is generated by operation of windpowered generators with a strong peak at a frequency which is the product of the rotation rate and the number of blades. It is refracted in the same manner as higher-pitched sounds and will therefore have limited range except under extraordinary weather conditions. The natural wind also generates infrasound especially at places like ridgelines where the terrain causes it to be exceptionally turbulent. Such infrasound is of widespread prevalence in some locations downwind from windy mountain ridges, such as Boulder, Colorado, and is not known to have any environmental impact. Special devices are required to detect it. Infrasound from windfarms is therefore expected to have no environmental significanct.

Finally, it should be noted that the intensity of impact in areas adjacent to windfarms will be proportional to the density of population in those areas. Because windfarm sites are characteristically barren and windswept, they are not preferred sites for habitations, and population will be extremely sparse.

E-3.4--INDIRECT LAND USE IMPACTS ARISING FROM GASOHOL PILOT PLANT ACTIVITIES

The off-site extraction/production of fossil fuel or biomass resources for pilot plant steam generation could impact existing land use patterns elsewhere. A rough estimate of the magnitude of such changes is presented in Table E-3.4.1, shown below.

If a fossil fuel is utilized for steam production is more than likely that the source would be acquired from an existing supply. Thus, assuming a reliable resource (supply) throughout the ethanol plant's lifetime, little to no change in present land use is expected to occur for the case(s) of natural gas or oil. Furthermore, the life-long coal extraction impact (possibly 1.5 acres) should also be negligible. The impacts following from straw utilization will be discussed in the next appendix.

Table E-3.4.1--Estimated Annual Land Use Requirements to Supply the 1680 GPD Pilot Plant with Fuel(s) for Process Heat

Fuel Type	Land Utilized (in acres)
Lignite coal	0.06[a]
Residual (No. 6) oil	0.31[b]
Natural gas	0.45[c]
Wheat straw (local source)	548.6[d]

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[a] Utilizes the coal gasification scenario assumptions of 24,000 extractable tons per acre, an HHV of 6800 Btu/lb. (as received), and a daily input of 5.9×10^7 Btu over a 348 day per year operating schedule.

[b] Utilizes the following Energy Alternatives assumptions: an average of 5 acres per 10^{12} Btu/yr on land production (p. 3-24) and 10.3 acres/10^{12} Btu/yr for refinery-related activities, excluding pipeline transport (see Table 3-6, p. 3-34).

[c] Utilizes the following Energy Alternatives assumptions: an average of 0.62 acre/10^{12} Btu/yr on land production, 21.8 acres/10^{12} Btu/yr for gathering and product distribution, plus 0.266 acres/10^{12} Btu/yr for processing prior to distribution and sale (all factors taken from Table 4-6, p. 4-20).

[d] Assumes the ACR heat requirement of 32,000 Btu/bushel (wheat) input and P.J. Starr, et al.'s figure of 1.167 potential tons of residue per acre tilled for wheat production are correct. Also assumes an 80% field collection efficiency and an 80% biomass-to-process steam converison efficiency (at the plant).

E-3.5--CROPLAND AREA UTILIZED AND ENVISIONED LAND USE IMPACTS ARISING FROM THE BURNING OF STRAW AT THE GASOHOL PILOT PLANT

As the 1680 GPD pilot ethanol plant will utilize about 641 bushels per day (or 9385 acres per year), the level of crop usage should have a negligible adverse, or even possibly beneficial, impact on the present agricultural activities of Valley County. If Patrick J. Staar, et al.'s (1978) residue factor is utilized (see Table E-3.4.1), slightly more than six percent of the cropland area designated for ethanol feedstock needs to be harvested for the generation of process steam. However, if more conservative residue yields (Sitton and Gaddy 1976) are combined with lower Btu feed (i.e., stoking of moist, loose straw fragments having an HHV of about 5800 Btu per pound), the residue-field requirement increases to about 1200 acres. In either case, care must be taken not to exceed a given area's ability to supply such material if potential loss of soil tilth/fertility or soil loss via wind/water erosion is to be avoided. The USDA has determined that only Class I type land can sustain semi-continuous crop residue removal without seriously impairing its agricultural value (Graham, et al. 1976); however, the EPA states that the percentage of residue safely removable from a given tract is not definitive (ERDA 1977).

Given the fact that a considerable portion of Valley County's land area is classified as Class III or greater, the minimization of environmental impact via application of "no-till" farming methods (ERDA 1977, p. 6) should be considered. Such a gathering program should therefore be carefully designed to optimize logistical/economic effectiveness, consequently allowing competitive fuel costing against coal, gas, or residual oil-fired furnace systems.

E-4.0--VALLEY COUNTY PUBLIC ACCEPTANCE

E-4.1--INTRODUCTION

Key agencies and organizations in Valley County and the Fort Peck Indian Tribal Council (see Table E-4.1.1) were requested to prepare letters stating how they could be impacted by the social factors associated with the various re-use scenarios. These responses were based on data supplied by a standardized information document (Exhibits E-4.1.2a through E-4.1.2f) which provided a brief description of the various re-uses and labor force required per phase, the regional marketability of the product, the pollution associated with each re-use, and the ownership of the various alternatives. Letters of response are presented as Exhibits E-4.3a through E-4.3n.

Table E-4.1.1--Agencies and Organizations Responding to Request for Evaluation of GAFB Re-Use Social Impacts

Fort Peck Tribal Executive Board
Valley Resource Council
Corps of Engineers
Montana Department of Fish and Game
Glasgow Public Schools
Glasgow Police Department
Glasgow Public Welfare Department
Montana Highway Department
Mountain Bell Telephone Company
Fort Peck Tribal Executive Council
Valley County Development Council
Seventeenth Judicial District
Valley Electric Co-op
Glasgow Post Office

The Montana Energy and MHD Research and Development Institute, Inc.
Post Office Box 3809
Butte, Montana 59701
(406) 494-6100
FTS 587-6100

Exhibit E-4.1.2a--Cover Letter

November 8, 1978

Mr. Norman Hollow
Tribal Chairman
Ft. Peck Indian Reservation
Poplar, Montana 59255

Dear Mr. Hollow:

Montana Energy Research and Development Institute, Inc. under contract to the Old West Regional Commission, is in the process of preparing Environmental Impact Assessments of proposed reuse options of the Glasgow Air Force Base. The options include:

- A coal gasification plant
- An integrated agricultural facility
- A modular housing industry
- A wind turbine manufacturer
- A railcar repair facility

In an effort to prepare a comprehensive EIA, Montana Energy Research and Development Institute, Inc. would like to request a position paper, to be prepared by the tribal council, addressing the various reuse options at the base. This paper to be included in the social impact assessment section of the EIA should provide information of the attitudes and opinions of the members of the Souix and Assiniboine tribes.

I would like to deliver the available information of the reuses in a personal presentation at the tribe's convenience.

For any questions, please contact Maurice Robinette, P. O. Box 3809, Butte, Montana (406-494-6267).

Thank you for your cooperation.

Yours truly,

Maurice Robinette

Maurice Robinette
Sociologist

MR:nc

cc: Karen Barclay
Mark Burrell
Terry Kirkland

Exhibit E-4.1.2b--Standard Information Document - A Coal Gasification/Ammonia Facility for Glasgow Air Force Base

DESCRIPTION: A Coal Gasification/Ammonia Facility for Glasgow Air Force Base

Coal gasification is the process of converting coal to synthetic natural gas (SNG). The Lurgi fixed-bed process projected for Glasgow Air Force Base (GAFB) will upgrade the gasifier product (450 Btu/scf) to pipeline quality SNG (950Btu/scf). This gas is largely methane (CH_4), and can be used to supplement conventional natural gas supplies. The facility envisioned for GAFB would be a self-contained Lurgi plant capable of producing 150 mmscfd SNG and 1000 tons per day anhydrous ammonia. The ammonia can be used as a fertilizer. Known Valley County geologic characteristics (e.g., coal volume per acre and total resources) appear to preclude the utilization of in-county reserves, even if the economic and environmental feasibility of extracting the coal can be resolved. Projected water requirements exceed the amount of water available to the plant. A pipeline and a large storage pond (with at least 30 days reserve water supply) would have to be constructed. A 48 MW power deficit would require modification of existing delivery services and possibly the construction of additional generating facilities.

As GAFB is located within an extensive agricultural region, the inclusion of nitrogen processing as a component of a gasification facility could possible serve immediate cropland operations. There are indications of increasing industrial confidence in profitable ammonia synthesis from coal-based SNG. This favorable view is probably due to the increasing price differential between intrastate natural gas and coal. With the apparent fertilizer surplus this tight market, imperfections, logistical problems, and other customary problems and delays could result in severe local or worldwide shortages. However, the lack of a definitive marketing analysis, including variation in cost per fertilizer unit, cost of capital and price of product, necessitates the view that ammonia production facilities at GAFB should not exceed capacities of 1000 tons per day, i.e., a typical, economically viable size. Furthermore, the potential coal conversion/ammonia plant planned by the Dreyer Brothers, Incorporated (a subsidiary of Burlington Northern Railroad Company) to be sited near Circle, Montana certainly clouds the economic viability of such an operation elsewhere in the state.

The Lurgi plant proposed for location at GAFB would be self-supporting; it would include all necessary process systems, utility and pollution control facilities, tankage, and other physical support in addition to possible electric power generation, if required. The design is based on commercially proven process equipment and a history of actual performance of Lurgi-designed plants. It will achieve an overall service factor of at least 92 percent annually. In this process coal is contacted counter currently with a steam-oxygen mixture to produce a crude product of gas, steam, tars, ammonia, and sulfur compounds. Further processing via shift conversion, rectisol gas purification steps yields high Btu, pipeline quality SNG. In addition to the synthetic gas, other potentially marketable products include tar, tar oils, naphtha, ammonia, phenols, and elemental sulfur.

Exhibit E-4.1.2b--(Continued)

POLLUTION

Levels depend on design--affects are assumed to be minor. Various pollutants include SO_x, NO_x, HC, CO, flourine, mercury, ammonia, carbonal sulfides, aldehydes, particulates and other miscellaneous gases.

LABOR

Construction phase requires 1200 the first year, 2100-2500 the second year, 1000 the third year, and 350 for the following six months. Production phase will start with six supervisors, 16 technicians, two equipment operators, and five construction field support personnel. This will increase in seven years to 80 supervisors, 25 technicians, 330 equipment operators, and 20 field construction support.

OWNERSHIP

Independent Investor

MARKETABILITY

Locally and regionally.

Exhibit E-4.1.2c --Standard Information Document - Integrated Aricultural Facility

DESCRIPTION: Integrated Agricultural Facility

In order to meet the objective of economical ethanol and by-product production at Glasgow Air Force Base (GAFB), an integrated agricultural processing facility (IAF) which can be scaled to meet the needs of regional farm operations is proposed. This facility largely will be energy self-sufficient and will attempt to cycle many components of the looped system. These are:

1) An enclosed livestock feedlot,
2) A meat processing facility,
3) An ethanol/gasohol plant,
4) A series of bio-gas generators, and
5) A high-protein algae-culture pond.

The entire cycle initiates with inputs of wheat, barley (and possibly other local agricultural products), alfalfa, cattle feed, water, heat (boiler steam and solar), and bentonite. Manure, low Btu snythetic natural gas (SNG), electricity, distillers dried grains and solids (DDGS), offal, fusel oil, CO_2, and other minor by-products are produced during the cycle. The major outputs are industrial grade ethanol (95% V/v), gasohol blend (using 100% v/v ethanol), beef, hides, biomass, and fertilizer.

Energy and materials are cycles through the component structure. Manure excreted by cattle is anerobically digested to produce SNG (approximately 65% methane) which is utilized to generate the electricity necessary for processing both the manure-sludge and the diluted milled grains used in ethanol production. High Btu steam produced by "flashing off" hot underground insulated steel distribution system is used to distill and process the pre-ethanol diluted milled grain mixture. The anhydrous ethanol produced after processing is blended with unleaded gasoline to yield high octane gasohol. Distiller's dried grains and solids are separated from the fermentation solution and either can be marketed or cycled to the feedlot for use as a food supplement. The feedlot cattle will be slaughtered after a 120-day process period, and the carcasses and hides may be marketed locally. Offal and other organic by-products can be cycled to the bio-gas digesters. Digested "thin slurry" (processes supernatent) will be used to grow high-protein algae in small solar heated ponds. The harvested single-cell protein (biomass) can serve as a further food supplement for the cattle.

POLLUTION

Designed for minimal pollution and product recycling. No air or water violations. Some unpleasant odors. Possibility of trace element accumulation from sludge.

Exhibit E-4.1.2c--(Continued)

LABOR

Thirty-one total including butchers, mechanics, engineers, cowboys, clerical, and supervisory. Construction period of 12 months would employ 75 skilled and unskilled workers.

OWNERSHIP

Independent investors and local cooperatives

MARKETABILITY

Local for gasohol and some beef may be regional.

Exhibit E-4.1.2d--Standard Information Document - Energy Conscious Modular Housing Industry and Building Materials Distribution Center

DESCRIPTION: Energy Conscious Modular Housing Industry and Building Materials Distribution Center

Preliminary suitability and feasibility studies on the use of Glasgow Air Force Base (GAFB) as the site for manufacture of energy conscious modular homes and a building supply materials distribution center were completed in conjunction with Grizzly Manufacturing, Inc., of Hamilton, Montana, and Transportable Homes, Inc., of Butte, Montana. The physical plant at GAFB appears particularly well suited for use as production facilities in the manufacture of modular homes. Space is a prime consideration in the building of modular homes and GAFB aircraft hangers offer excellent space provisions. Together with installed rail service, abundant storage capabilities for equipment and supplies, existing overhead cranes and paved out-of-door storage and transfer areas, GAFB supplied the major components required for modular home building.

The scope of this proposed manufacturing operation is variable. Present housing market conditions in northern Montana and the five-county area surrounding GAFB indicate present and future demand for minimally five modular homes per week. If housing market conditions for a larger area, including Canada, all of Montana, and the states immediately adjacent to Montana, are considered there exists suitable potential markets for ten or more modular homes per week.

Most modular home builders offer a range of four to six standardized homes as well as homes built to custom specifications. Homes range in size from two bedroom to four bedroom with optional finish work including divergent heating systems ranging from baseboard electric and ceiling radiation to wood burning stoves and fireplaces. Passive solar heating and cooling systems are currently available only on a custom basis.

Montana Energy Research and Development Institute in conjunction with Grizzly Manufacturing is designing modular homes which incorporate passive solar heating and cooling systems. These homes are being designed for use on Montana's "high-line" and would be produced at GAFB.

Additionally, modular townhouses, two-plexes, motels, office buildings, and restaurants can be manufactured on a custom order basis using the GAFB facilities.

Manufacturers' representatives have also expressed interest in the suitability of GAFB facilities in the production of mobile homes. A combined modular home-mobile home manufacturing industrial park appears feasible. Utilizing existing rail facilities for bulk material shipments. the competitive stance for this type of development and the base is greatly improved. Potential exists for the development of a wholesale building materials distribution center which could serve contractors and building material retail outlets in northeastern Montana. Additionally, modular home component structures (walls, roof trusses, etc.) can be manufactured at GAFB and shipped as components

Exhibit E-4.1.2d--(Continued)

for site assembly throughout the U.S. and Canada.

POLLUTION

Solid wastes in the form of packaging such as cardboard, styrofoam, and metal banding would vary according to production rates.

Other emissions and effluents would be minimal and would be contained on site or with the structure.

LABOR

Painters, carpenters, and unskilled (number depends on size of operation, see description).

OWNERSHIP

Independent Investor

MARKETABILITY

Locally to within a 500-mile radius including parts of Canada.

Exhibit E-4.1.2e--Standard Information Document - Wind Turbine Generator Manufacturing

DESCRIPTION: Wind Turbine Generator Manufacturing

The scope of operation for Wind Turbine Generator manufacturing at Glasgow would be determined in large part by the actual work to be performed there. It is unlikely that facilities would ever be installed at Glasgow for producing materials needed in the construction of wind turbines. For the most part, materials, such as steel and components, such as blades, generators, and gears would have to be shipped in by rail and by truck.

The most probable type of plant for Glasgow would then be a production-line assembly type plant for manufacturing wind turbine systems. Nearly 20,000 wind generators in the 100-200 kw output range are considered for construction. Production estimates do not consider any market outside of Montana nor do they consider the very possible market for smaller-sized machines of 20-40 kw output. This latter size machine would also be produced in the same facility.

Let's now assume that a crew of five workers working a forty-hour work week could fabricate or produce one machine. Similarly then, if facilities were available, one hundred (100) workers, working a standard week could produce twenty machines. Therefore, at the end of one year's production, the facility at Glasgow could produce approximately 1000 machines with a generating capability of 100-200 MW depending on whether 100 kw or 200 kw machines were assembled. In any event at this rate of production, the plant could employ 100 workers and would have potential market in Montana alone for approximately 20 years of production. This approach then lays the groundwork for a very exciting possibility of producing 100 MW/year of wind electric generation in Montana for at least 20 years.

POLLUTION

Minimal--paint booths and welders would be controlled within the building. Some solid wastes from packaging. Effluents adequately disposed of on Base. Possible hazard to birds.

LABOR

Number is dependent on project size and market demand. Construction aspect would employ approximately 100 people (75 hired locally) and would include welders, electricians, painters, and technicians. 100-115 people would be needed to maintain a wind farm.

OWNERSHIP

Government subsidized program through DOE

MARKETABILITY

Locally and regionally.

Exhibit E-4.1.2f--Standard Information Document - Railcar Repair Facility

DESCRIPTION: Railcar Repair Facility

The scope of operation is largely determined by the type and volume of work performed, number of employees, prevailing weather, and capital investment required. A railcar repair facility situated at V.I.P. (Glasgow Air Force Base) should be capable of heavy freight car repair. This requires facilities, equipment, and manpower capable of complete disassembly, repair, and reassembly of cars. Railcar repair facilities have a tendancy to stay away from on-site fabrication of parts, with part fabrication contracted to individual jobbers. To keep costs and capital expenditures within reason, fabrication of parts would be limited to special cases at the V.I.P. facility, thus reducing the need for specialized and expensive equipment.

The proposed facility would be capable of repairing two to three cars simultaneously, with an estimated labor requirement of 120 employees (based on railcar maintenance estimates). Skilled labor (carmen and welders) comprise approximately 90 percent of the labor requirements of a railcar heavy repair facility.

While weather conditions may or may not require railcar repair facilities located in the central U.S. to have indoor shops to accomplish heavy repairs, cold temperatures, high winds, and snow in northeastern Montana preclude the use of an outdoor car repair facility. A minimum of two buildings would be required at the V.I.P. proposed site: a workshop building and a material handling and storage building.

POLLUTION

Sandblasting with emission controls, painting with emission controls, welding gases, and noise contained within structure.

LABOR

120 for construction of 20 months (mostly unskilled) and 120 for operation consisting primarily of skilled laborer (carmen and welders).

OWNERSHIP

Burlington Northern or private investor

MARKETABILITY

Primarily coal transportation from Fort Union Basin to the Midwest, Great Plains, and Southwest.

IN REPLY REFER TO:
Environmental
Quality

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS

P. O. BOX 637
FORT PECK AGENCY
POPLAR, MONTANA 59255

December 1, 1978

Maurice Robinette
Montana Energy Resource and Development
Box 3809
Butte, Montana 59701

Dear Mr. Robinette:

You have asked for our comments relative to the environmental aspects of the various projects being considered to utilize the facilities at Glasgow AFB.

It should be pointed out that the Fort Peck Tribes have gone on record requesting that the air quality designation of the reservation area be changed from Class II to Class I to protect their natural environment from further degradation.

The Bureau of Indian Affairs will support the desire and goals of the Fort Peck Tribes in maintaining the quality of their environment.

As you know, each of your proposals would requre and environmental assessment to determine the need for an environmental impact statement under the Environmental Policy Act of 1969.

The two most obvious proposals needing further assessment for environmental reasons would be the Integrated Agricultural Facility involving an enclosed livestock feedlot, meat processing, ethanol/gasohol plant, bio-gas generator and a high-protein algae-culture pond and the coal Gasification/Ammonia Facility used to convert coal to synthetic natural gas (SNG) and the production of nitrogen fertilizer.

I presume you have discussed or plan to discuss this matter with the Fort Peck Tribes. Thank you for the opportunity to review your proposals.

Superintendent

cc: Norman Hollow, Chairman
Fort Peck Tribal Executive Board

Nov. 24, 1978
Glasgow, Montana

Mr. Maurice Robinette
Montana Energy & MHD Research & Development
Box 3809
Butte, Montana 59701

Re: Five plans for Utilization of GAFB.

Dear Sir:

The Valley Resource Council, a group of farmers, ranchers, business and professional people concerned about uncontrolled development, make the following recommendatons for use of Glasgow Air Force Base.

Plan #1 Energy Conscious Modular Housing Proposal. Full Endorsement.

Plan #2 Railcar Repair Full End orsement.

Plan #3 Integrated Agricultural Proposal. Full Endorsement
Article 1) An enclosed livestock feedlot should be enlarged upon to include conversion of safeguard buildings to pig palaces as proposed by a local rancher.

Plan #4 Wind Turbines for electrical generation. Full Endorsement.

Plan #5 Coal Gasification/Ammonia Facility. No Endorsement now.

Due to the relatively small amount of rainfall and the thinness of our top soil, we fear that the Northeastern Montana area may be very susceptible to permanent damage from pollutants of either air or water.

The Valley Resource Council is also concerned about the social impact of such a facility with its large influx of temporary construction workers. Our law enforcement agencies, our schools and other local service suppliers would be strained with a probable increase in taxes on the present resident population. We must take a cautious look at any project that will result in a short term profit for a few with a long term deteriation in the quality of life for many.

Silverbow County, probably the most industrialized of all Montana counties, not only has to bear the ugly scars of mining and the defoliation of the countryside by pollutants but also is chronically depressed economically. Butte and Anaconda have repeatedly had to get state money to supply county services.

With this in mind, the Valley Resouce Council would want to see the completed Environmental Impact Study as required by the Montana Major Facility Siting Act. Also, we would need to have a full explanation of amount of power needed, whether this power would be produced locally or not and type of power i.e. coal powered generation, hydroelectric or other.

Until this information is supplied we cannot endorse this proposal.

Sincerely Yours

Don Grimsrud

Don Grimsrud, Pres.
Valley Resouce Council
Glasgow Montana 59230

DEPARTMENT OF THE ARMY
OMAHA DISTRICT, CORPS OF ENGINEERS
MONTANA AREA
P. O. BOX 208
FORT PECK, MONTANA 59223

MROFO-MO

30 November 1978

Mr. Maurice Robinette
The Montana Energy and MHD
Research & Development Institute, Inc.
Box 3809
Butte, MT 59701

Dear Mr. Robinette:

In response to your letter of 9 November 1978, in which you asked for an assessment of the social impacts the options mentioned in the referenced letter would have on our agency and its functions, we offer the following comments:

a. Any or all of the options would result in a greater use and demand on our recreational facilities. Since recreation is one of the values and benefits of our Montana Area, we feel this impact would be beneficial. We would expect to extend and develop our existing facilities as demands and needs increase.

b. The realization of any or all of the options would have a beneficial effect on the businesses of an area, since the influx of people in the area utilizing the recreational facilities would also increase local business activity. Our local businesses have the capability to handle the increase.

c. School impact as a result of these activities would be minimal as we foresee it.

d. Housing impact at Fort Peck would not be a concern inasmuch as the housing is controlled and with the housing available at the VIP and the local area, it seems there would be no serious problems of accommodating the influx of people.

e. Law enforcement impacts so far as recreational impacts are concerned we do not consider as a problem. Ordinarily we would match our enforcement contract requirements with the usage of the recreational facilities. Vandalism, which is always with us it seems would probably increase, but would not be a significant factor.

We believe the above items are the major impacts we would experience and we look upon them as being favorable, all things considered.

Sincerely yours,

D. C. Beckman

D. C. BECKMAN
Area Engineer

STATE OF MONTANA

DEPARTMENT OF
FISH AND GAME

Route #1-210
Glasgow, MT 59230

November 30, 1978

Ms. Karen Barclay
Montana Energy and MHD Research
  and Development Institute, Inc.
P.O. Box 3809
Butte, MT 59701

Dear Ms. Barclay:

My staff and I have reviewed your letter of November 9, 1978, and the five attached proposals for possible development at the Glasgow Air Force Base (GAFB). Our comments are limited to local wildlife and recreation impacts.

In general we see two elements associated with development that can or will impact this area's recreation and wildlife values. The first is the impact of people. The number of people, the length of their stay, the security of their jobs, the time frame of their movement into and out of this are important. We are interested in the willingness of employers to assist the existing community and their new employees in adapting to each other. The interest of the newcomers in personally investing themselves in the affairs of our area will also be important.

There are many landowners in northeast Montana who still talk of trespass problems, vandalism, rustling and poaching losses and other bad experiences they associated with the height of military activity at the GAFB. I am sure there were many positive aspects of the military's presence in this area; but, the irresponsible action of more than a few caused private land and access to be closed, hurt the local wildlife resource, damaged the reputation of consumptive wildlife activities in general and caused elements of the community to divide and pull inward. It seems in rural eastern Montana the more gradual the people impact over time the better the community adapts and the less the impact on wildlife values.

The second impact element is the waste a development produces. The amount and type of waste and how it is handled and disposed determine the impact. We are especially interested in wastes that will affect air and water quality and possibly vegetative growth away from the production site.

We have checked your proposals with these two elements in mind. Right now it is our feeling that the modular home industry (at five units/month) and the agricultural facility would each have a negligible environmental impact at the GAFB and would probably not require Fish and Game review.

The wind turbine and railcar repair industries would each have minor to moderate initial impacts. The degree would depend on how management handled the construction phase and worked with their temporary construction force.

The gasification idea is a much larger project and can hardly be compared with the other four proposals. If the Ft. Peck Reservation gets a Class I air quality standard, I don't know how such a facility could be constructed. In any case, such a project would require considerable coordination with surrounding counties and local communities. The Fish and Game would want to review specific plans as they affect water and coal development, air quality, emission control, law enforcement, recreation development and waste disposal.

We appreciate this opportunity to comment. The wind turbine, modular housing, and the integrated agriculture development ideas were new to us and are interesting as well as encouraging. If you think we can be of further assistance, please let us know.

Sincerely,

R L Johnson /by [illegible]

Richard L. Johnson
Regional Supervisor

RLJ/MWA/lmw
cc: Jim Posewitz, MDF&G, Helena

GLASGOW SCOTTIES

SENIOR HIGH SCHOOL (406) 228 2485
Ronald F. Stegman, Principal
E. N. Warner, Vice Principal

SCHOOL DISTRICT NUMBER 1 & 1-A
Eunice Moen, Clerk-Business Manager
(406) 228-2406

Gary A. Sauter,
Principal & Elementary Coordinator
Irle School, (406) 228-2215

Glasgow Public Schools
Gary F. Martin, Superintendent
(406) 228-2406
Post Office Box 28
GLASGOW, MONTANA 59230

JUNIOR HIGH SCHOOL (406) 228-2406
Sidney D. Sulser, Principal
Warren H. Gamas, Special Services Coordinator

ELEMENTARY SCHOOLS
Dennis O. Idler, Principal
North Star School (406) 524-6410

Donald G. Rath, Principal
East Side School (406) 228-8451
South Side School (406) 228 2911

November 20 1978

Mr Maurice Robinette
Montana Energy & MHD Research Institute
P O Box 3809
Butte Montana 59701

Dear Mr Robinette

This letter is in response to your request for information relating to possible impact that various re-uses of the Glasgow Base and the effect to the school system.

The North Star school currently has an enrollment of 180 students, the school could handle 600 students. The Junior High school located at the base has been closed for a number of years. It it were to be re-opened it would require some major expense due to its being empty. This school could handle an enrollment of 360 students.

Of the alternatives that were discussed from an impact viewpoint it would seem that the coal gasification plant is possibly the only alternative that could pose some problem.

The figures that you provided me, that using 90.55 percent figure of employees having families and a 1.62 child-student ratio of that figure, it would seem the impact could be handled.

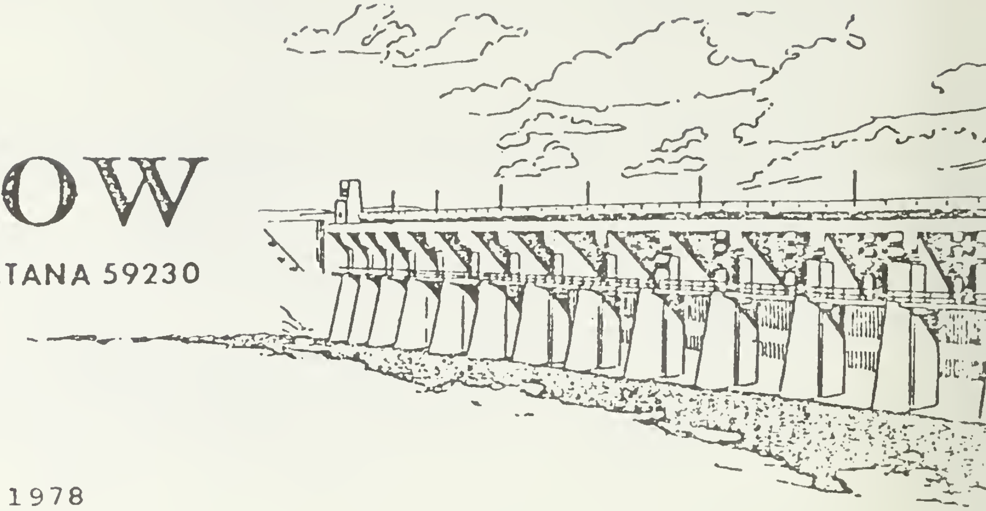
I trust this information provides you with the necessary assessment of the situation.

Sincerely

Gary F. Martin

Gary F Martin
Superintendent
School District #1
Glasgow Montana 59230

CITY OF
Glasgow
GLASGOW, MONTANA 59230



November 21, 1978

Mr. Maurice Robinette
Montana Energy & MHD Research
Boc 3809
Butte, Montana 59701

Dear Mr. Robinette,

In reference to your questionaire of November 9th of options to be considered at the Glasgow Air Base or (Valley Industrial Park). Any one of the options listed definitely would be of benefit to our area. I am very concerned as most people are of the economy of Glasgow and Valley County.

I think one of the biggest concerns with the citizens in the county is the tax base and any relief would be welcome, industry fine, but not a big influx of people. I realize this would be great in the smaller communities but not always the most practical.

Glasgow is the county seat of Valley County with the population of approximately 7,000 people with an estimated additional 8,000 people in the county. We have a 10-man police department.

In 1968 the Air Base was closed down which resulted in a 16% population decrease which did effect the police activity. Population increases or decreases effect the level of police activities. The period of time in 1968 when the Air Base closed until activities started to increase in the last few years the overall police activities increased over 12%.

I feel the type of a business in a community would definitely have an enviromental impact, whether it be by the type of personnel employed or the ecology aspect.

Gateway To Fort Peck Recreation Area

The experiences we in the Police Department have been confronted with are:

(a) A high employee turn-over results in a lower class of people which result in a troublesome attitude.

The caliber of people involved in an industry in the area seems to be the concern.

Sincerely,

Thomas L. Grewe
Chief of Police

COUNTY OF VALLEY
Department of Public Welfare
Box 272
GLASGOW, MONTANA 59230

December 1, 1978

Montana Energy and MHD Research
and Development Institute Inc.,
P. O. Box 3809
Butte, Montana 59701

Attention: Maurice Robinette

My staff and I appreciate this opportunity to respond to the proposal outlined in Karen Barclay's letter concerning development of the Glasgow Air Force Base.

The positive affects of increased employment opportunities would be that hopefully some of our able bodied recipients would become employed. The number of recipients has usually increased during the winter months so if work could continue year around it would benefit most. Since most of our adult ADC recipients are female, hopefully your proposal will meet some of their employment needs.

Our experience with transient population, such as would be attracted in the construction phases of the proposal, is that social problems increase as do the needs for supportive services. The increases in needed services directly affects my staff.

We already need an additional social worker because of needed services at the Base. An increase of up to 2500 construction workers would mean increased problems in family breakdown and child abuse and neglect and would increase the need for day care and foster care facilities. This could mean our Social Service staff might need to increase by up to three social workers, two home attendants and a clerical worker.

It would be beneficial for the families of the workers, if consideration was given for the opening of a day care center.

We anticipate that the demand for services would also increase in welfare assistance, food stamps and medical requests.

For the employed the need would depend on the salaries paid and the medical benefits available. If the salaries and benefits are low then demand increases.

Since many of the new employees will be without funds some thought should be given as to how they can meet necessities and pay rent before getting their first check.

Proposals such as these often attract more people than are needed to meet the employment quota. Job seekers have limited resources so again cost for necessities and transportation will increase. Some of these people stay on and become permanently on our rolls. Also this staying behind will happen when the construction phases are over and there is no longer work. Are there any plans to move the workers to new construction sites?

The increase demands for welfare assistance could also mean additional eligibility technicians and clerical.

Administration costs of our programs could increase as we would need more office space, etc.

Since the county portion of our budget is supported by county property taxes any increase in staff, administrative costs and welfare assistance increases these taxes. Because the Base property usually has not been taxed these costs fall back on the county's property owners. Consideration should be given in your porposal for ways to increase income to the county from property taxes because of increases in the poor fund, school fund, etc.

If any additional information is needed please let us know.

Sincerely,

Delores M. Shelton

Delores M. Shelton, County Director III
for Phillips, Valley, Sheridan, Daniels
and Roosevelt Counties.

DMS:nb
cc: Valley County Commissioners
Darlene Riggin, ETS
Mike Hermanson, SWSI

STATE OF MONTANA
DEPARTMENT OF HIGHWAYS

December 8, 1978

Glasgow Air Force
Base Development
Alternates

Maurice Robinette
Montana Energy & MHD Research
& Development Institute
P. O. Box 3809
Butte, Montana 59701

Dear Mr. Robinette:

This is in reply to your letter of November 9, 1978 to our Wolf Point Division.

From the information furnished it is our opinion that the Railcar Repair Facility, the Integrated Agricultural Facility or the Wind Turbine Manufacturing should not have a significant effect on the highway system or the traveling public. However, a Coal Gasification Plant or an Integrated Housing Industry probably would.

The Coal Gasification Plant itself probably would not impact our facilities but the tremendous number of people involved in the construction and to a lesser extent in the later operation probably would have a significant effect. The main problems to be addressed would be the increase in traffic volumes on the various roads and highways in the area and the effects of those increases in present traffic patterns.

The main impact that we see in conjunction with the Integrated Housing Industry is the transport of the completed units on the highway system. Of course if they plan to haul them by rail there should be no significant impact on highways, however they will probably want to transport them on the highways.

Some items to be addressed would be the number of units to be moved, the width of the units, the weight of the units, and the anticipated haul routes.

If you have any further questions from us, please feel free to call.

30-SCK/js

Very truly yours,

Stephen C. Kologi

Stephen C. Kologi, P. E., Chief
Preconstruction Bureau

cc J. R. Beckert
H. G. Wheeler
D. D. Gruel
V. D. Borden
D. V. Borgen

Mountain Bell

December 11, 1978, Helena, Montana

Mr. Maurice Robinette
P. O. Box 3809
Butte, Montana 59701

Dear Mr. Robinette:

An analysis of future impacts of the five proposed reuse options for the Glasgow Air Force Base on Mountain Bell's employment reveals that there would be no significant changes in the work forces in the Glasgow exchange.

As you are aware, the Glasgow Air Base is served by the Valley Rural Telephone. The reuse proposals either calls for employment of local area persons or use of base housing for workers relocated from outside the community. Mountain Bell would experience expansions in the trade and service sector of Glasgow's economy and an evaluation of telephone main gain shows that each proposal could be adequately handled by the present personnel. Major basic assumptions for the above-mentioned analysis are:

1. Agriculture will continue as the economic base in the Glasgow economy.
2. Major influences of personnel from outside the Glasgow Economic Base Area will use available air base housing.

Yours truly,

L. F. Marquardt

L. F. Marquardt
Financial Manager

MOT:ti

FORT PECK PLANNING DISTRICT
ASSINIBOINE & SIOUX TRIBES
P. O. BOX 115
POPLAR, MONTANA 59255

406-768-3690

December 12, 1978

Maurice Robinette
Sociologist
The Montana Energy & MHD
Research & Development Institute, Inc.
P.O. Box 3809
Butte, Montana 59701

Dear Maurice:

Enclosed is the Tribal Executive Councils position paper on the reuses of Glasgow Air Force Base. The council has requested that you send several copies of the EIA to them when it is completed. I would also appreciate a copy for imformation to be included in part of the Class I Air study.

If we can be of any further assistance to you, please contact us.

Sincerely,

David Johnson,
Land Use Planner

DJ/mrm

Enclosure

cc: Norman Hollow, Chairman
Caleb Shields, Councilman
Jackie Weeks, Executive Director

FORT PECK TRIBAL COUNCILS POSITION CONCERNING INDUSTRIAL DEVELOPMENT AT GLASGOW AIR FORCE BASE

The Tribes have been informed of five potential reuses of the Glasgow Air Force Base. Of these five, a railcar repair facility, a wind turbine manufacturer, a modular housing industry, and an integrated agricultural facility appear compatible with our ideas of beneficial and acceptable development.

We realize the need for jobs and a stimulation of the local economy but cannot endorse any type of industrial development which may jeopardize our health, environment or the productivity of our lands.

A Coal Gasification Plant at Glasgow?

With the Presidents new policy for energy independence, it is inevitable that the country will turn more and more towards the burning of coal to meet our energy needs. Coal technology is rapidly advancing today but even the State of the Art is not sufficient to ensure environmental stability and well being. The Fort Peck area contains fairly large reserves of low sulfer lignite which could easily be mined if we wished. We realize there is a good potential to become rich from our coal, but we also realize the many adverse effects of strip mining. Similarly we also realize that locating a coal gasification plant in Glasgow will greatly increase the economic base of Valley County but with current technology, the impacts of our environment and health are far from acceptable. A coal gasification and ammonia production facility located at Glasgow Air Force Base is not acceptable nor, compatible with our major source of income and rapidly advancing industrie, namely agriculture. A facility as such has the potential to slow down the development of agriculture here, it could reduce crop yields and limit the production of cattle, not to mention its potential to worsen the already high incidence of respiratory disease in northeastern Montana.

The Fort Peck Tribes are currently undertaking the study to determine the benefits and limitations of redesignating the Reservation to Class I Air quality standards. We are not considering Class I Air to stop progress and economic development on or near our Reservation but we are considering it to insure well planned, environmentally and socially acceptable compatible development. In general, we feel Class I Air on the Reservation will not isolate our reservation any further nor will it protect our peoples way of life from the effects of energy development planned for the region. It will lessen the expected impacts of these developments by protecting the reservation's clean air. The benefits of redesignation to surrounding areas are similar to the benefits of our reservation itself. Both are rural areas agriculturally productive and dependant societies whos traditions and current land use patterns are compatible with the industrial controls imposed by Class I regulations. Class I Air on the Fort Peck Indian Reservation will not stop economic development in that area. It will insure well planned and environmentally compatible industrial development and prevent blind industrialization which has so many times caused the destruction of rural communities. Along with this it will also insure clean air, the most important natural resource to all living things.

Perhaps in time, when technology advances to the point where these problems are completely understood and alleviated a facility as such may become more acceptable.

In conclusion the Fort Peck Tribal Executive Board fiercely opposes the construction of any large scale coal burning facility which cannot meet clean air standards on or near the Fort Peck Reservation.

Valley County Development Council

Courthouse Annex, Room 2
Post Office Box 832
Glasgow, Montana 59230
Tel: (406) 228-9389

December 12, 1978

The Montana Energy and MHD Research
and Development Institute, Inc.
P.O. Box 3809
Butte, Montana 59701

Gentlemen:

Herein are remarks pertaining to your request for our input regarding some suggested future uses of the Glasgow Air Force Base. These have surfaced through your environmental assessment contract of the facility.

MANUFACTURING SITE FOR MODULAR HOMES, MOBILE HOMES, AND OTHER BUILDINGS

It is agreed that such a business would fit in well with the "ready made community" and the available structures capable of housing such an industry.

POLLUTION

This appears to be minimal and is adequately covered in your statements.

LABOR

Although numbers are not mentioned and would depend upon the industry development, it is felt that filling these needs would not be a problem. The area has a history of peaks and valleys in labor needs which have always been met in past projects. There are also capabilities on the Base of training in various skills through the Family Training Center. This could possible expand to technical assistance for "on the job" training. The stability of the job would have a high affect on the level of capable labor.

OWNERSHIP

Independent Investor - It is the local goal to utilize these fine facilities and provide employment while at the same time attracting industry at a reasonable cost to cover the upkeep of the facilities.

MARKETABILITY

Within the radius mentioned there are several Indian Reservations which have a projected need for considerable housing of this type. Securing such contracts with an additional natural market should be a recognizable basis for such an industry.

The projected study and use of solar heating units in such homes, combined with other sources of energy, should lead to greater marketability.

RAILCAR REPAIR FACILITIES

This is well covered in the description. At one time there were negotiations between Burlington Northern and a potential coal customer to establish such a facility at Valley Industrial Park (VIP) for coal car assembly and repair. This did not materialize. It is understood there is such a coal car renovation project now developing at Miles City. However, it seems there is a great need for such an enterprise just in the repair and maintenance of rail cars used in the shipment of grain. There seems to be a continual shortage of these for Montana grain.

Coal shipment will continue to be an ever expanding industry in Montana. The facilities here are of a capacity capable of handling such an enterprise.

POLLUTION

This is adequately covered.

LABOR

Similar conditions would apply to this as our remarks on the Modular Home section. We do not see it as a problem.

OWNERSHIP

Burlington Northern - Here again, this would be putting the facilities to productive private industrial use and the employment of people.

MARKETABILITY

Your remarks are adequate in relation to coal shipment. However, we would like to suggest consideration of grain car renovation as well.

INTEGRATED AGRICULTURE FACILITY

The subject is well covered. A continual effort has been made to expand the Agri-Industry of the area and production from our resources in a more total integrated use.

1) An enclosed livestock feedlot - development is dependent upon the location and use of facilities by other industry.

2) A meat processing facility - again, a natural tie-in with a feeding program if adequate numbers justify it.

3) An ethanol/gasohol plant - there is considerable interest locally in such a plant with a local organization now formed. Nationally recognized expertise has been brought in by MERDI to meet with this group.

4) Bio-gas generators and high protein by-products of the above operations are important in feasability of such operations.

WIND TURBINE GENERATOR MANUFACTURING

This subject is also covered in the several categories. Looking to the need for alternate and supplementary sources of energy, this would fulfill a portion of this from a natural force. Modest use of this source was used on Montana farms in the 1930's prior to Rural Electrification. With today's advanced technologies, the market for such proposed production could be considerable in an integrated system.

COAL GASIFICATION/AMMONIA FACILITY FOR GLASGOW AIR FORCE BASE (VALLEY INDUSTRIAL PARK)

General remarks: The Base facilities have had prior study which shows that the installation has a potential capability to serve as an "Energy Park." In 1976 the Canadian Province of Alberta announced that the supply of natural gas being exported to Montana would be phased down over a rather short span of years. Montana, at that time, was receiving roughly 65% of their natural gas supply from Canada. Coal gasification studies were turned to as an alternate synthetic gas source of supply. Glasgow Air Force Base was looked to as a priority site location for such a plant. Your project description shows the knowledge which was gained from the work.

The emergency is not as great as in 1976. New agreements have been worked out with Canadian sources in addition to gas production within the state. It is felt alternate energy sources should continually be pursued.

In a very recent action, the Fort Peck Tribal Council is petitioning for a Class I Air designation for the Fort Peck Indian Reservation. The Glasgow Air Force Base is within three miles of the western boundary of the reservation. If the Class I Air designation is granted it will no doubt be a considerable factor in the development of a coal gasification plant.

Sincerely,

Manson H. Bailey, Jr.
Executive Director

MHB/pjp

LEONARD H. LANGEN
DISTRICT JUDGE
SEVENTEENTH JUDICIAL DISTRICT
OF THE STATE OF MONTANA

P. O. BOX 1110
GLASGOW, MONT. 59230
TELEPHONE: 228-2221

December 13, 1978

Mr. Maurice Robinette
P.O. Box 3809
Butte, MT 59701

RE: ENVIRONMENTAL IMPACT ASSESSMENTS OF PROPOSED RE-USES OF GLASGOW AIR FORCE BASE

Dear Mr. Robinette:

You requested a letter from me advising you of the social impact on the court system of Valley County with reference to various proposed re-uses of the Glasgow Air Force Base.

The 17th Judicial District consists of Valley County and Phillips County. The supporting staff for the 17th Judicial District Court system consists of:

Office of the Clerk of Court, Valley County Courthouse, staffed by a clerk and a deputy clerk

Office of the Clerk of Court, Phillips County Courthouse, staffed by a clerk and a deputy clerk

Youth Probation Office, staffed by Chief Probation Officer, Glasgow, MT who performs all of the work in Valley County and supervises the work in Phillips County. Also on staff is a Deputy Probation Officer who handles Phillips County and resides at Malta, MT.

Parole Officer who handles Phillips and Valley counties (17th Judicial District) and also handles Roosevelt, Daniels and Sheridan counties (15th Judicial District) Parole Officer resides at Glasgow, MT.

District Judge who resides at Glasgow, MT and commutes twice monthly at regular times to hold court in Phillips County. Also commutes additional to Phillips County as work demands.

Secretary to District Judge who works at Glasgow, MT. She also performs secretarial work for the Youth Probation Officer and the Parole Officer.

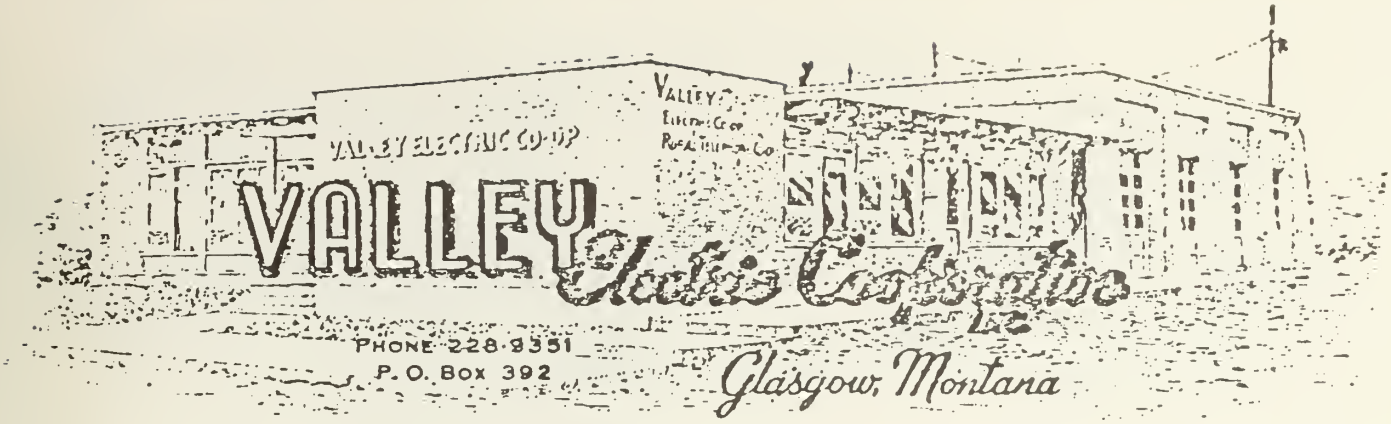
Any increase in population in Valley County resulting from the contemplated uses of the Glasgow Air Force Base will increase the work load of the 17th Judicial District Court system.

I think that the expected population increases can be handled with the present staff. The only exception might be the Youth Probation Office. If the juvenile cases increased materially it might be necessary to add an assistant probation officer for Valley County.

Very truly yours,

Leonard H. Langen
District Judge

LHL/js



VALLEY Electric Cooperative
Phone 228-9351
P.O. Box 392
Glasgow, Montana

December 15, 1978

Maurice Robinette
Montana Energy & M.H.D. Research & Development
Box 3809
Butte, Montana 59701

Dear Mr. Robinette,

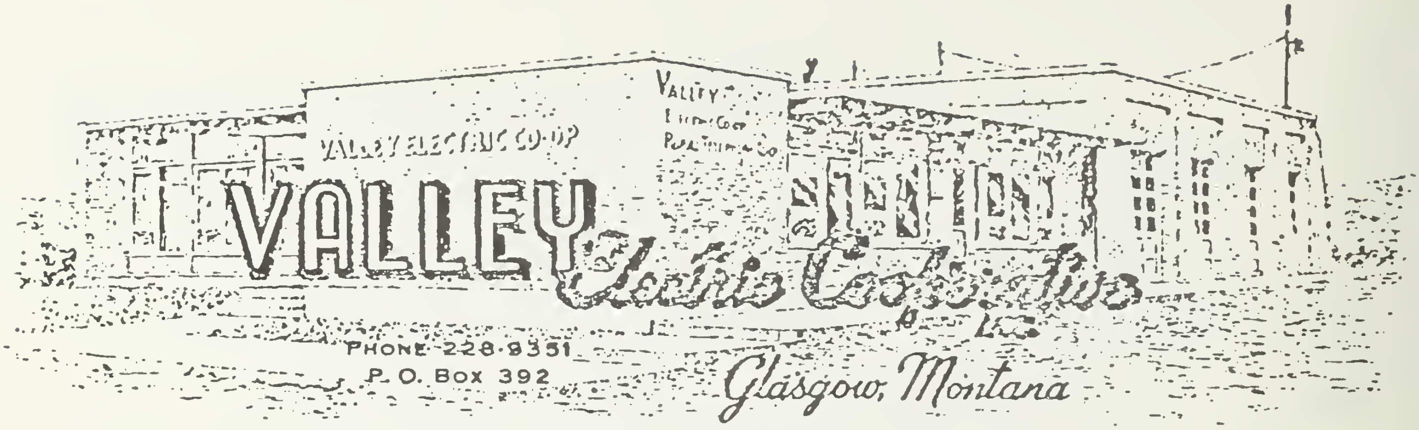
In answer to the list of different industry possibilities at V.I.P. (former Glasgow Air Force Base) you left me. I'd like to make these comments:

On the Modular Home Industry possibility: I think this would be an excellent industry. It is not too large, it's not pollutant and would provide employment for a lot of people, depending on size. Anything in this area would be very good.

Railcar Repair facility: This also would be a very good industry and also provide a valuable service with all the coal we have being shipped out. It is limited though. With Burlington Northern being the only company using this facility it looks good, but it is limited.

Integrated Agriculture facility: Parts of this proposal are good, but when you start talking large feedlots or large pig producing facilities, you are talking a lot of polution. (Air) I was raised on a farm and I know what a small barnyard can produce in air polution and I can imagine what a large scale operation of, say, pigs would be like. Large feedlots and large pig producing facilities would have to be my last choice after it's found out that no other industries are available for the base.

Wind Turbine Generation Manufacturing: I like this idea, but I have my doubts as to weather generators in the class you're talking about (100-200 kw) would be an economically marketable product say to farmers, ranchers, and residents, because of the price. I think they would be very good if they are marketable to the general public.



VALLEY Electric Cooperative
PHONE 228-9351
P.O. Box 392
Glasgow, Montana

Page 2 of 2 December 15, 1978

Coal Gasification/Ammonia Plant: A very good idea, but not logical or feasiable as long as our state has the restriction it has on plants of this size. When the laws are changed this is a good possibility.

Generally an industry at V.I.P: I'd like to make the following remarks:

V.I.P. has so many possibilities it is almost beyond the realm of our imagination. Where else in Montana can a facility be found that has everything needed for industry as this place has. But to industrialize this community we are going to have to take a logical look at this facility and do it on a slow basis. We should have tax breaks from the state to promote industry to come in. I think we are going to have to get our heads out of the clouds and quit thinking about these real big industries and concentrate on small individually owned industry.

We can't fill that base overnight and we might as well get that through our heads. To fill it overnight would require one big industry and you don't put a big industry together overnight. We can and should look at these for the future, but right now we'd better concentrate on smaller ideas or we'll never get it going. Let's concentrate on the smaller ideas now and start plans for bigger ones later.

Yours truly,

Kenneth H. Berreth

Kenneth H. Berreth, Mgr.
Valley Electric Co-op

KHB/kr

UNITED STATES POST OFFICE
GLASGOW, MONTANA 59230

OUR REF:

DATE: DECEMBER 15, 1978

SUBJECT: GLASGOW AIR FORCE BASE MAIL SERVICE:

P.O.CL: 1

TO:
MR. MAURICE ROBINETTE
MONTANA ENERGY & M.H.D. RESEARCH INC.
POST OFFICE BOX 3809
BUTTE, MONTANA 59701

Dear Mr. Robinette;

As per your request the following is a statement of impact on Postal Service and mail delivery at the Glasgow Air Force Base (GAFB) relative to the proposed possible industrial developement thereon.

At the present time the Postal Facility at the base is operated as a contract Rural Branch. This means that it is not staffed bycareer postal employees but is operated as a branch of the Glasgow, Montana Post Office by an individual under contract with the United States Postal Service. It is therefore the responsibility of the contractor to furnish quarters, certain office equipment and utilities. Mail delivery service is accomplished through the utilization of Neighborhood Collection and Delivery boxes, commonly known as Cluster boxes, by city letter carriers operating from the Main Post Office in Glasgow. The Cluster boxes are in place to serve approximately 800 family housing units. Additional Cluster boxes are at the Glasgow Postal Facility to increase this total to approximately 880 family units. These," ON HAND " additional units could be furnished by the Postal Service but the responsibility and cost of installation would have to be born by the Valley Industrial Park (VIP) as the landlord and operator of the Glasgow Air Force Base. There after, all additional Cluster boxes would have to be furnished and installed by the VIP at no cost to the Postal Service.

Total housing units on the Base consist of 1233 units. 267 units are single story MCP units and 966 are two storied Capehart units. There are several multi-storied dormitory type buildings which, if utilized for single persons, could receive mail service to the individual building with the installation of a single delivery box or groups of individual mail boxes at a single point in each building.

Currently we are delivering approximately 450 families on the Base. We could absorb an additional 250 families with existing employees and equipment with a small expenditure of additional man hours. Full utilization of all housing units on the base would call for the hiring of one (1) additional Part Time employee and the acquisition of one (1) additional ½ Ton delivery vehicle.

I cannot forsee any major problems or obstructions at this time in the expansion of mail service at the Glasgow Air Force Base if the need should arize due to any expanded industrialization at the Base by VIP or tennant occupants.

If you should need any further information concerning this facet of developement or utilization of the Glasgow Air Force Base please do not hesitate to contact me.

Respectfully

Joe Eastman, Postmaster

Glasgow, Montana 59230

E-5.0--EXISTING ENVIRONMENT--GLASGOW AND VICINITY

SECTION E-5.0--EXISTING ENVIRONMENT OF GLASGOW AND VICINITY

This section presents detailed technical information and discussion pertaining to the natural and socioeconomic environments in the immediate vicinity of GAFB. The interdisciplinary analysis of the former aspects includes geological information, soil classification, meteorological and air quality data, aquatic macro-invertebrate analyaes, periphyton analyses, game and non-game fish species inventories, big game habitat diversity and utilization analyses, small mammal trapping results, bird species listings (by season), waterfowl survey results, special mammalian/arian surveys and vegetative site descriptions and analyses. The socioeconomic and cultural sections include economics and social data, agricultural statistics, commerce statistics, government taxes, Glasgow employment levels, personal income data for Valley County, and archaeological surface reconnaissance results.

E-5.1--PHYSIOGRAPHIC CHARACTERISTICS

E-5.1.1 Geologic History

Eastern Montana was largely innundated by seas of variable depth and chemical composition during major portions of the Paleozoic Era. These periods (e.g., late Cambrian, middle Devonian, Mississipian) resulted in the deposition of materials that were later consolidated into sandstone, linestone/dolomites, shales, and halitic strata.

Periodic orthogenic and sedimentation cycling throughout the Mesozoic Era resulted in region-wide structural movements of the Paleozoic strata of north central Montana and deposition of marine and fresh water muds (now shales or limey shales) and organic residues (now lignite), respectively. Near the end of late Cretaceous time and before the recession of the last marine seas, volcanism in western Montana resulted in the deposition of volcanic ash in eastern Montana; these materials would be later consolidated into the bentonitic shales of the Bearpaw Formation. Such activity was proceeded by a vigorous episode of mountain building which took place at the end of Cretaceous time in eastern Montana.

During the Tertiary Period of the Cenozoic Era, erosional debris arising from the uplifting Rocky Mountain Chairs collected as sands, muds, etc. to considerable depths in the Glasgow area. Extensive swamps developed, giving rise to the future coal reserves of eastern Montana. Several states of Pleistocene (Quarternary) continental glaciation passed through large portions of northeastern Montana. This resulted in diversions of the major pre-glacial drainage patterns, as well as modifying the region's geomarphology and topography. Holocene strata found in the valleys of Porcupine and Cherry Creeks (as well as other tributaries to the Milk or Missouri River) have developed in response to the very recent redistribution of surficial and onconsolidated sediments which have accumulated since the middle Tertiary Period.

A. Stratigraphy

The stratigraphic record of eastern Montana was initiated by a series of Archaen-aged (non-Beltian) metamorphosed sediments and igenous instrusions. Grouped as Pony gneiss in western Montana, this Precambrian basement series had not been mapped or described for the eastern portion of the state. The rock is generally dense (specific gravity of 2.95), with a petrology that includes interbedded hornblonde gneiss, biotite gneiss, biotite schist, and minor calc-silicate minerals.

A direct study of the Paleozoic lithologic sequence in the Little Rockies (approximately 100 miles west south west of the GAFB) reveals a basal section of Cambrian-aged, interbedded limestone and shale strata capped by conglomeratic quartzite. Siluro-Devonian strata include shales, sandstones, and dark-toned, fetid limestones. The upturned, massive Mississippian-aged limestone and evaporite strata figure prominently in the younger rocks of this area.

The initiation of the Mesozoic record is apparently marred by a stratigraphic discontinuity which has eliminated the Traissic strata. The late Jurassic section includes the Morrison Formation and grades into the Kootenai Formation of the Lower Cretaceous Period. These periods are composed of calcareous shales, fire-grained massive sandstones, variegated (blue, green, red, gray) shales interbedded with brown to yellow sandstones, carbonaceous shaley sandstones and capped with a fresh water gastropod-bearing limestone. The overlying Lower Cretacous Colorado Group consists of marine shales and shaley sandstones; near the base are a few unique beds of bentonite and minor coal seams. The Montana Group rests upon the Colorado Group (see Figure E-5.1.1.1) and includes the Eagle Sandstone, Claggett Shale, Judith River Formation, Bearpaw Shale and Fox Hills Formation. The first three memebers of the group are observed only in drilling logs near GAFB. The Bearpaw Shale is considered to be the principal bedrock unit at the base; it is a thick, monotonous sequence of dark bentonitic sandy and silty shales and contains widespread gypsum beds and abundant marine fossils. The upper Cretaceous is terminated regionally by the Hell Creek Formation; it is lithologically similar to the Fox Hills Formation and is a continuation of continental sedimentation.

The lowest stratigraphic unit of the Cenozoic Era's Tertiary Period is the Fort Union Formation. It includes the Tullock (oldest) member, the Lebo Shale member, and the Tongue River (youngest) member; all three are lithologically very similar and defy distinction locally. The lattermost member consists of light gray to light yellow sandstones or shales extensively intercolated with coal seams of varying thicknesses.

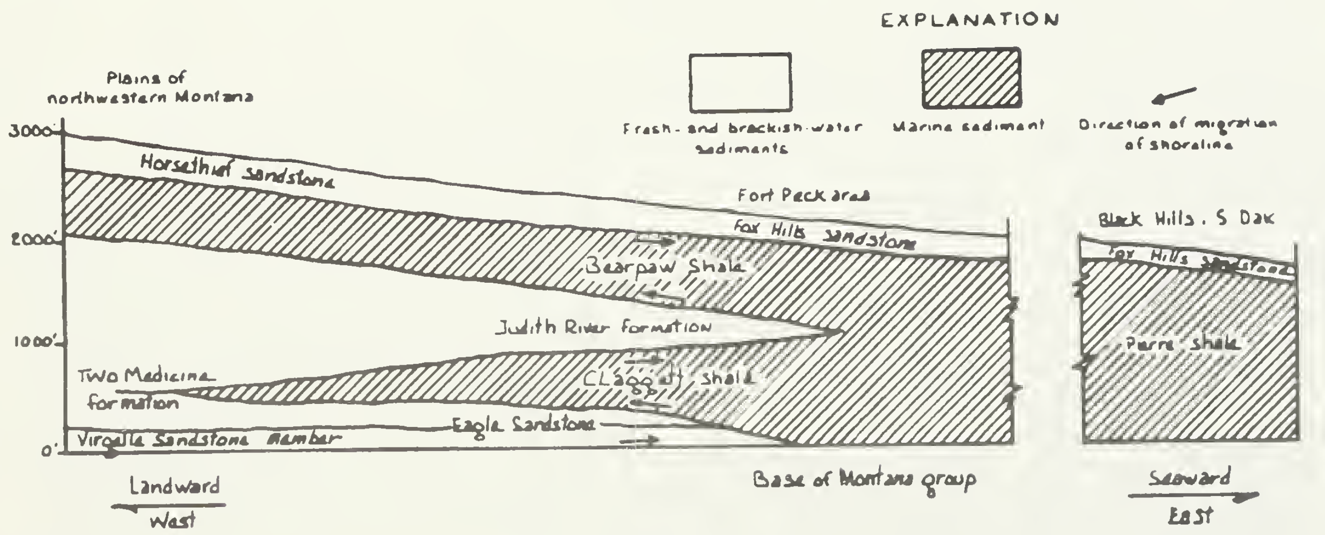


Figure E-5.1.1.1--Generalized Stratigraphic Diagram of the Montana Group

Source: Stebinger 1914.

2° Source: Federal Energy Administration, Siting Energy Facilities at Glasgow Air Force Base, Volume I, Washington D. C., November 1975, p. 196.

The preglacial surficial deposits in the Glasgow area include the Miocene-Pliocene aged gravels of the Flaxville Formation. This unit is overlain by the unconsolidated Wiota Gravels of the Pleistocene Epoch. The Gravels are discontinuous near Glasgow but widespread beneath the glacial drift north of the Missouri River; however, extensive exposures border the valleys of Porcupine, Cherry, and Little Porcupine Creeks and the Milk River. The consequences of Pleistocene glacial activity include a moderately calcareous, heteorgeneous textured (but clay dominated) ground moraine, fluviolacustrine sediments plus channel and terrace outwash deposits. The Holocene alluvial deposits were mapped along the major drainages of the region range in character from fine sand-silt assemblages in the Upper Missouri Sub-basin to the near residual soils in the uplands toward the GAFB.

B. Structure

The following discussion has been extracted and quoted verbatim from the MERDI/FEA Energy Siting document (1975, Vol. I, pp. 200-202).

1. "Regional Structural Setting

The major bedrock structures near GAFB are large domes and folds with formational dips no more than 2 degrees. Superimposed upon these broad features are several regional fault sets and local but rare areas of intense folding and/or faulting. Though faulting is relatively common throughout the region, individual breaks are small and are not generally extensive.

The Bowdoin Dome, 65 kilometers west of the air base, is the nearest large structural feature. It is a near-circular dome on a high structural ridge trending approximately east-west toward the air base. The dome has approximately 180 meters of closure over a diameter of about 105 kilometers. Approximately 130 kilometers south of the area an east-west-trending syncline is the dominant bedrock structural feature. This is the Blood Creek-Sheep Mountain structure, a long trough plunging gently into the Williston Basin, 160 kilometers east at the North Dakota state line. In the area of Glasgow, the regional dip of all sedimentary units is to the southeast, and at this point the synclinal flexure controls these attitudes. Further north the structural ridge causes a reversal in dip.

The maximum structural relief of the region is 1,067 meters from the crest of the Bowdoin Dome to the bottom of the Williston Basin. The surface between these three structures is only semiregular with local reversals in dip and only a general regularity in trend."

2. Local Structural Features

Within 15 kilometers of the air base the overall structural features include the Wolf Creek anticline and small scale northeast-trending faulting. Both are important in siting considerations.

The Wolf Creek anticline is a regional flexure extending from the Bowdoin Dome toward the Williston Basin. Its axial plain trends through the air base area. Dips on either limb are less than 2 degrees, and at the air base the Bearpaw Shale is horizontal. As a result, the bedrock unit within 15 kilometers of the site is the Bearpaw shale.

Faulting in the Great plains has not been studied in great detail. Jensen et al. (1964) describes the sequence of faulting in the vicinity of Glasgow as follows:

a) 'Thrust faulting from north to south yielded imbricate structure, repetition of beds and relatively steep dips...

b) 'Normal faulting after thrusting pressure was dissipated.'

In this commentary, the normal faults are described as more persistent than the thrust of slight displacement (206 meters) and relatively short. Because the Bearpaw Shale slumps and the surface is covered with gravels and ground moraine, the normal faults were not traced any great distance.

In the current study, the photogeologic evidence suggests that one fault set with an attitude of N.32 E. dipping steeply north and south persists from Glasgow north to the air base. A number of these traces trend across the runway. Many of these minor faults displace the Wiota Gravels and ground moraine; therefore, the movement along the faults has been more recent than the glacial activity from which the moraine was derived. Immediately south of the base a local fracture trend of N. 70 W. cuts the ground moraine and Bearpaw Shale. The area over which this trend occurs is less than several square kilometers, and the individual lineaments appear truncated by the N. 30 E. faults."

C. Seismic Characteristics

The following discussion on the region's seismicity has been quoted verbatim from pages 228, 231-2 in Volume I of the MERDI/FEA Siting Energy Facilities at Glasgow Air Force Base.

1. "Setting

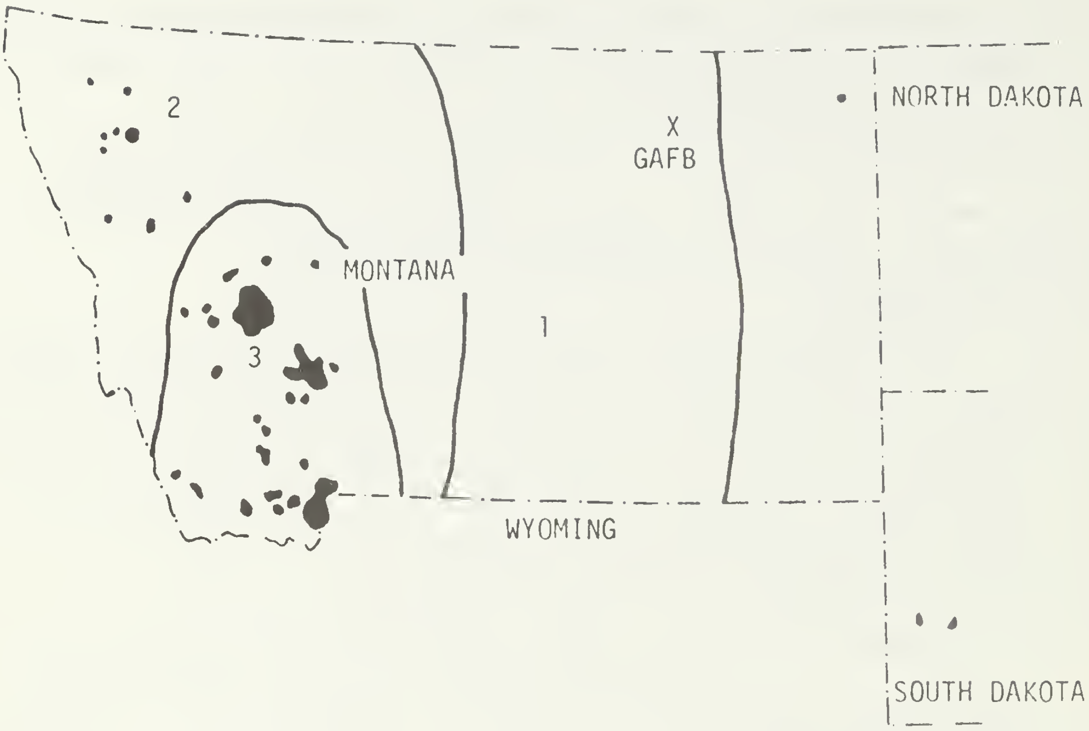
The Glasgow area is at the edge of the Great Plains, immediately east of the Rocky Mountains and is in an area considered geologically stable. Recent crustal construction suggest a change in thickness along the eastern border of the Rockies. This zone apparently correlates with a decrease in seismicity to the east."

2. "Correlation with Geologic Structures

Commonly, seismic events correlate very closely with geologic structures or activities, particularly faulting and volcanism. The Glasgow and Froid areas are similar geologically. Structural characteristics of both are an underlayer of flat-lying sediments covered by a veneer of gravels. The only possible correlation between structure and seismic activity is either with subsidence connected with the Williston basin or with buried faults.

Geologic maps of the Froid area do not indicate faulting, but from recent studies of the Glasgow area, faulting is probably present.

In light of these data it seems probable that the seism of 1943 was related to movement along faults, possibly marginal to the Williston basin. It would be logical to expect other events of the same intensity spaced at some considerable distance in time. Studies by Algermissen (1969) suggest that from a strain release point of view the Pacific west has been 86 times more active than the Central Plains, 16 times more active than the eastern United States, and 6 times more active than the Rocky Mountain area. The Glasgow site is immediately off the Rocky Mountain front on the Great Plains. Figure (E5.1.1.2) is a seismic risk map of Montana indicating the relatively low risk at the Glasgow AFB site."



KEY

Zone 0 - No damage.

Zone 1 - Minor Damage: Distant earthquakes may cause damage to structures eith dundamental periods greater than 1.0 seconds; corresponds to intensities V and VI of M.M.* scale.

Zone 2 - Moderate Damage: Corresponds to intensity VII of the M.M.* scale.

Zone 3 - Major Damage: Corresponds to intensity VIII and higher of the M.M.* scale.

Note.--This map is based on the known distribution of damaging earthquakes and the M.M.* intensities associated with these earthquakes; evidence of strain release; and consideration of major geologic structures and provinces believed to be associated with earthquake activity. The probable frequency of occurrence of damaging earthquakes in each zone was not considered in assigning ratings to the various zones.

*Modified Mercalli intensity scale of 1931.

Figure E-5.1.1.2--Seismic Risk Zone

Source: MERDI/FEA, 1975.

3. "Historic Incidence

In compilation up to 1970 of earthquakes for the western Mountain States, of 116 recorded seisms only one was recorded in the northeast section of the state. This quake occurred at 21:25 hours, 24 June 1943 and had an intensity value of VI on the 1931 modified Mercalli scale. This earthquake was in southern Sheridan County, Montana, approximately 115 kilometers east of the site. The damage consisted of a 'well constructed' granary at Froid being cracked to the point where wheat flowed out. Other damage consisted of plaster and chimneys being cracked at Froid, Redstone, Reserve, and Homestead. Records indicate that in spite of the fact that the event was considered of local significance, the area in which damage was felt was 2,800 square kilometers.

E-5.1.2 Mineral Resources

A. Coal

Valley County lies within the northeastern boundary of the Williston lignite coal district which in turn is a portion of the Fort Union geological formation; this formation probably contains the largest lignite and sub-bituminous coal reserves in the country, if not the world.

B. Oil and Gas

The eastern Montana area contains numerous gas and oil fields and produces well over half the state's total petroleum output. Significant portions of the total gas reserves are associated with the Bowdoin Dome (west of GAFB) while the nearest oil field is located east of the base in central Roosevelt County.

C. Bentonite

Bentonite is a commercial name given to volcanic ash that has been altered to a type of clay consisting primarily of the mineral montmorillonite. This clay may be used in the production of lightweight aggregate for construction purposes or as an additive in rotary drilling muds for oil and gas exploration. Currently, a particularly pure source is being extracted from a pit mine about 20 miles west-south-west of Glasgow, Montana.

D. Clay

Clays are hydrous aluminum silicates commonly mixed with many mineral impurities (e.g., chlorite, limonite, quartz). The three broad categories based largely on chemical composition and crystal structure are the Kaolin group, the Illite group, and the Bentonite groups. Most of the deposits in Valley County are associated with formations of the Cretaceous and Tertiary Periods. Several clay pits have been productive in and near the county.

E. Sand and Gravel

Deposits of these materials correspond geographically to the distribution of Tertiary Period plateau gravels and are thus widespread throughout the eastern half of the county. A river of Flaxville Gravel lenses served as the source of aggregate for subgrade materials during the construction of the GAFB runway system.

F. Gypsum/Anhydrite

The eastern half of Valley County is underlain by extensive deposits of the hydrous and anhydrous forms of calcium sulfate (respectively gypsum and anhydrite). The Mississippian Period evaporite deposits lie at depths of several hundred meters; thus, their potential for profitable extraction is uncertain despite the potential uses of these materials in the chemical agricultural and metallurgical industries.

E-5.1.3 Soils

A. Introduction

This report, extracted verbatim from the MERDI/FEA document (1975), presents a general synopsis of the soil characteristics of central Valley County, Montana. The area covered by this study is approximately 200 square miles around Glasgow AFB. Detailed inventory and evaluation data were prepared by J. A. Icenhower and L. C. Bingham of the U.S. Department of Agriculture Soil Conservation Service in Glasgow, Montana in cooperation with the Valley County Soil Conservation District.

B. Background

1. Climate

The climate of northeast Montana is of the "continental type," with a large annual range in temperature and limited precipitation. Fort Peck Reservoir, to the south seems to have little climatic effect on the area except for brief periods of morning fog in the late fall; fog occassionally drifts northward from the lake before "freeze-up."

While the normal annual precipitation is only 12.27 inches, 9.26 inches, or 75 percent of this amount, normally falls during the 6 so-called "growing months," April to September; 4.47 inches, or 36 percent of the yearly normal, falls during the months of May and June.

2. Soil Types

In the survey area, the soils are of three basic types. These are the clays, loams, and sands which are commonly located on the higher elevated grasslands. The lower elevations, where the stream bottoms are located, contain a mixture of the eroded uplands. There are few dynamic land features like shale outcrops in this area.

C. Soil Classification Systems

Land use capabilities have been categorized into eight classes and several subclasses by the U.S. Department of Agriculture (USDA). The soil grouping is based on limitations of the soils, risk of damage when disturbed, and the difficulty encountered in their restoration.

Class I includes the soils that have few limitations, the widest range of possible use, and least risk of damage. The soils in the other classes have progressively greater natural limitations. Class VIII soils and land forms are so rough, shallow, or otherwise limited in usefulness that they do not produce worthwhile yields of crops or forage.

1. Soil Capability Classes

The eight classes in the capability system are as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, that limit their use largely to pasture, range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or to aesthetic purposes.

2. Soil Capability Subclasses

Soil groups within one class are designated by adding a small letter, e, w, s, or c to the class numeral, for example, IIIe. The letter e shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; w shows that water in or on the soil interferes with plant growth or cultivation (in some soils that wetness can be partly corrected by artificial drainage); s shows that the soil is limited mainly becuase it is shallow, droughty, stony, saline, or alkaline; and c, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or dry.

In Class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by w, s, and c, because the soils in Class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture range, woodland, wildlife, or recreation.

3. Highway Materials Classifications

The American Association of State Highway Officials' (AASHO) system of classifying soils is an engineering property classification. It is based on field performance of highways. According to this system, soils having about the same general load-carrying capacity and service properties are grouped to form seven basic groups. These groups are designated as A-1, A-2, A-3, A-4, A-5, A-6, and A-7.

D. Soil Properties Significant to Engineering

In the survey area the soils are, on the whole, not acceptable for use as engineering construction materials. However, throughout the area are deposits of gravel and sand of good quality. These deposits are generally undeveloped. A gravel deposit that is of significant size is located west of Highway 247 in the northwest corner of the GAFB. In addition, dirt roads constructed from soils in this area are generally quite durable. Dirt roads in the survey area are not dusty when dry or soggy when wet. The slow permeability of water into these soils contributes to the fact that roads in this area are not handicapped with sogginess because of water penetration.

1. Workability

The workability of these soils is good. For construction of utility ditches or for road backfill, the soil limitations are moderate. For the general use of these soils in sewage absorption fields, sewage lagoons, or sanitray landfill, the limitations of the soil is slight to moderate. The low permeability noted here in most soils is the main reason contamination of ground water or surrounding soil structures is slight.

2. Streambeds and Drainage Area Soils

Soils in the drainage areas are an accumulation of all the soil types. As a general rule, these soils are porous (of high permeability) and are mostly unsuited for building on or near, have a high flood characteristic, make poor sewage lagoons or absorption fields, and are not recommended for use in construction or building.

3. General Characteristics

The soils in the survey area are of a very low permeability. The loss of water is slight. All soils are favorable for pond reservoir, embankments, dikes, levees, and irrigation. Drainage of cropland and pasture is slow, mainly because of the permeability of the soils. The use of soils for terraces, diversions, and grassed waterways is favorable in the middle uplands, whereas the stream bottom areas are excluded from classification.

E. Agricultural Use Suitability

Use of these soils for agricultural cropping or livestock range is limited. There is a small amount of land used for rotational strip farming of wheat and barley in the survey area. However, much of this land is used primarily for summer livestock grazing. It should be noted that in the gully areas there may not be any topsoil at all due to erosion.

F. Soil Types

There are many soil types noted in the GAFB area. This section will name each one with its characteristics and specific limitations. Each soil series is generally named for a town or other geographic feature near the place where a soil of the series was first observed and mapped. Some soils are complex and cannot be described by one name alone. A combination of soil series names might be used which would describe soil types that are closely associated. See Figure E-5.1.3.1 for a map of the survey area indicating the soils designated by soil number.

1. Absher Series

The absher series are deep, well drained, nearly level to gently rolling soils on alluvial fans and terraces. Typically, absher soils are light brownish-gray loam. Mapping symbols that indicate absher soils are located in groups IV, VI, and VII. Permeability in absher soils is quite slow and these soils have poor crop and rangeland potential.

2. Aquic Ustifluvents

This is a miscellaneous land type of nearly level and gently sloping soils on low stream terraces, flood plains,

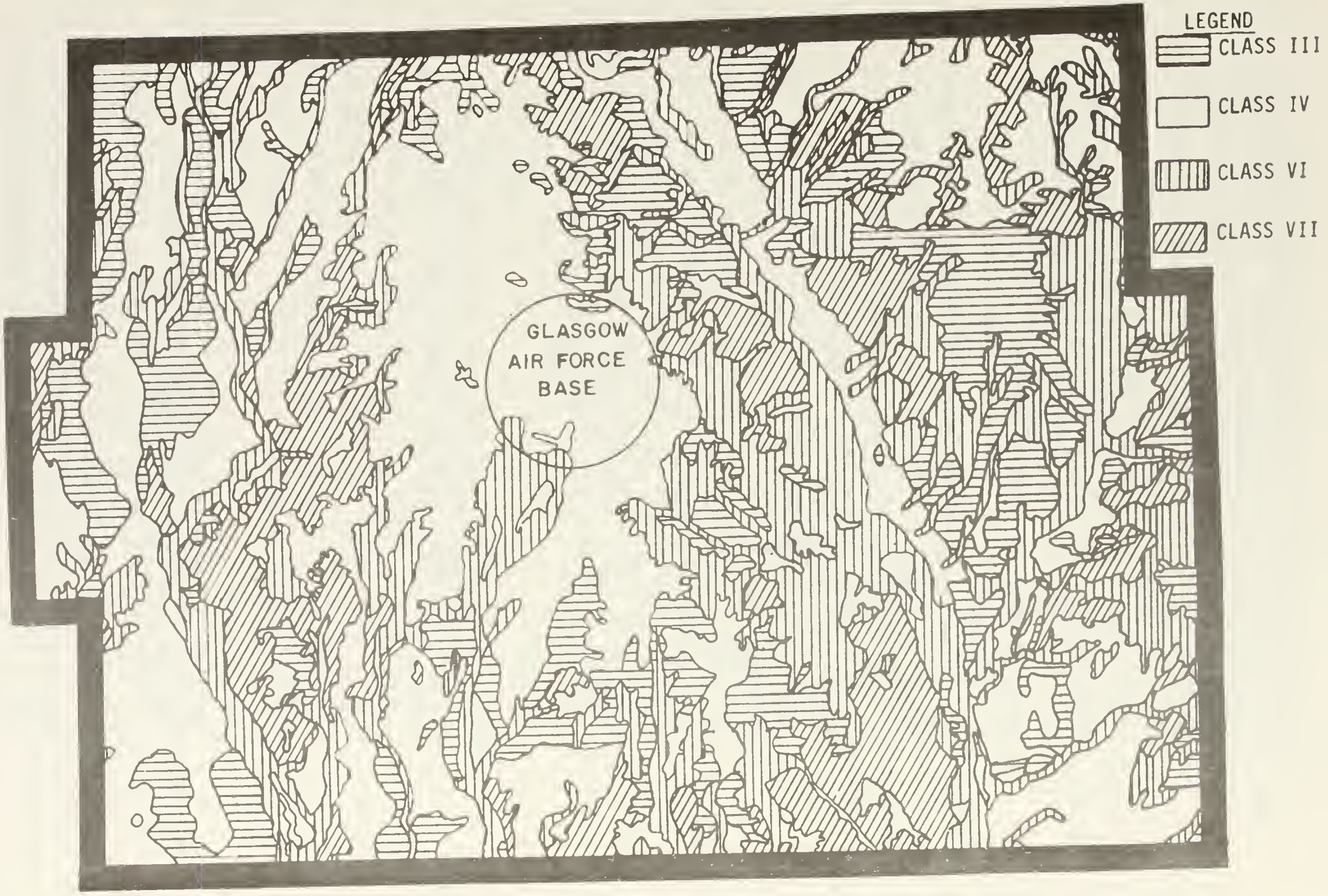


Figure 5.1.3.1--Soil Types by Classification Number

and alluvial fans. Soil textures are clay loam and clay. The mapping symbol that indicates aquic ustifluvent soils are located in group VI. Permeability in aquic ustifluvent soil is slow but variable according to location. As this soil is saline, it is not utilized for cropland. Native grasses that grow in this soil are western wheatgrass and saltgrass. This soil has severe to moderate soil limitations because of its great tendency to high flooding.

3. Attewan

The Attewan Series consists of deep, well-drained, nearly level, and gently sloping soils formed in alluvium underlain by sand and gravel on stream terraces and alluvial fans. Typically, these soils are a grayish-brown loam. The mapping symbol that indicates Attewan soils are located in group III. Permeability of these soils is slow but is very rapid below 24 inches. This soil type is not recommended for sewage absorption fields or lagoons. Although some of this soil type is used for cropland, it is used primarily as rangeland because its vegetation cover contains western and thickspike wheatgrass, needleandthread, green needlegrass, blue grama, and prairie junegrass.

4. Harlem Clay

The Harlem Series are deep, well-drained, nearly level soils on flood plains and low terraces. Typically, Harlem clay soils are gray and granular. Mapping symbols that indicate harlem clay soils are located in group III. Permeability of these soils is slow and not recommended for sewage disposal or irrigation. However, this clay is suited for pond, reservoir utilization. This soil is rated fair for cropland. Western wheatgrass, green needlegrass, sinterfat, and plains reedgrass are native to this soil type.

5. Harlem Silty Clay Loam

The Harlem Series are deep, well-drained, nearly level soils on flood plains and low terraces. Typically, Harlem silty clay loam soils are light brownish-gray, silty clay loam.

The mapping symbol that indicates Harlem silty clay loam soils is located in group III. Permeability of these soils is slow below 20 inches in depth, making them acceptable for use as ponds and reservoir use. This soil is not recommended for recreational uses (camp areas, picnic areas, play grounds, or trails). Native grasses noted on this soil type are western wheatgrass, green needlegrass, winterfat, and plains reedgrass.

6. Havre Gravelly Substratum

This phase of the Havre Series is a deep, well-drained, nearly level soil on low stream terraces. Typically, this phase of the Havre Series has a clay loam surface layer, stratified loam and clay loam subsoil, and underlaying material over sand and gravel at 40-60 inches. The mapping symbol that indicates Havre gravelly substratus soils is located in group IV. Permeability of these soils is moderate but is very rapid below 40 inches because of the underlying sand and gravel. The sand and gravel located below 40 inches is excellent for use in construction. The sand may need to be screened. Because of the sand and gravel these soils could be a possible source of groundwater pollution. This soil type is not recommended as rangeland, because of low annual grass yield.

7. Lisam

The Lisam Series are shallow, well-drained, gently rolling to hilly soils on stream dissected sedimentary uplands. Typically, Lisam soils are gray clay. Clay shales start at 12 inches below surface. Mapping symbols that indicate Lisam soils are located in groups VI and VII. Permeability of these soils is slow. These soils are not utilized as cropland or rangeland because of poor topsoil.

8. Marias

The Marias Series are deep, well-drained, nearly level to gently rolling and moderate sloping soils on upland plains and alluvial fans. Typically, Marias soils are grayish-brown, granular silty clay. The mapping symbol that indicates Marias soils is located in group III. Permeability of these soils is slow, which makes this a soil type favorable for a pond reservoir area. Good results have been achieved when this soil type is used as cropland. Native grasses include western wheatgrass, green needlegrass, winterfat, and plains reedgrass.

9. Nishon Loam

The Nishon Series are deep, somewhat poorly drained, nearly level soils in upland, undrained basins. Typically, Nishon soils are light brownish-gray loam surfaces, grayisn-brown prismatic clay subsoils and light clay underlying material. The mapping symbol that indicates Nishon loma soils is located in group III. Permeability of these soils is slow to moderate. These soils are ponded part of the year. All features are favorable for pond reservoir areas. Crops grow moderately well and the rangeland supports native grasses that include green needlegrass and western wheatgrass.

10. Phillips

The Phillips Series are deep, well-drained, nearly level to gently rolling soils on glacial till plains. Typically, Phillips soils are light brownish-gray clay loam. These soils represent a majority in the survey area. The mapping symbols that indicate Phillips soils are located in groups III, IV, and VI. Permeability of these soils is slow. All features are favorable for utilization as pond reservoir. Most cropland in the survey area is contained on this soil type; however, the majority of the balance is in rangeland.

11. Phillips Gravelly Substratum Variant

The Phillips gravelly substratum variant are deep, well-drained, nearly level and gently sloping soils on stream terraces and alluvial fans. Typically, Phillips gravelly substratum are light brownish-gray loam surfaces, grayish-brown/gray subsoils, and very gravelly loamy sand underlying material. The mapping symbol that indicates Phillips gravelly substratum variant soils is located in group III. Permeability of these soils is slow. However, below 30 inches permeability is very rapid because of the gravel and sand located in that strata. Pollution of groundwater might occur because of highly permeable sand and gravel below 30 inches. Use of these soils for cropland is noted by the low yield of wheat and barley. Native grasses that thrive in a moderately prosperous environment are western and thickspike wheatgrass, green needlegrass, winterfat, short-awn porcupine grass, needleandthread, and blue grama.

12. Scobey

The Scobey Series are deep, well-drained, nearly level to hilly soils on glacial till plains. Typically, Scobey soils are grayish-brown clay loam. The mapping symbols that indicate Scobey soils are located in groups III and IV. Permeability of these soils is slow, which makes it favorable for pond and reservoir use. These soils yield a moderate harvest in wheat and barley. These soils are fairly well suited for rangeland and wildlife rangeland.

13. Shale Outcrop

The mapping symbol that indicates shale outcrop is located in group VII. The shale outcrop is unsuited for all uses.

14. Sunburst

The Sunburst Series are deep, well-drained, gently rolling to hilly soils on glacial till plains and stream valley side slopes. Typically, Sunburst soils are grayish-brown and granular. The mapping symbols that indicate Sunburst soils are located in groups VI and VII. Permeability is slow for these soils. As these soils are on rolling hill sides, they are not utilized for sewage disposal application or as cropland. Native grass yield is moderate for rangeland, with western wheatgrass, green needlegrass, little bluestem, bluebunch wheatgrass, blue grama, and plains reedgrass.

15. Telstad

The Telstad Series are deep, well-drained, nearly level to gently rolling soils on glacial till plains. Typically, Telstad soils are grayish-brown, light clay loam. The mapping symbols that indicate Telstad soils are located in group III. Permeability of these is slow. All features of these soils are favorable for pond and reservoir use, but the slope of the terrain warrants special attention in this area. Cropland on these soils yield a medium wheat and barley harvest. Native grasses include western and thickspike wheatgrass, needleandthread, green needlegrass, blue grama, and prairie junegrass.

16. Thebo

The Thebo Series are moderately deep, well-drained, undulating to hilly soils on stream-dissected sedimentary uplands. Typically, Thebo soils are light brownish-gray and granular. The mapping symbols that indicate Thebo soils are located in group VI and VII. Permeability is slow in these soils; however, a clay shale underlayment causes an increase of absorption properties below 25 inches. These soils are moderate cropland soils with native grasses that include western wheatgrass, green needlegrass, winterfat, and plains reedgrass. Wildlife rangeland on these soils are rated poor.

17. Thoeny

The Thoeny Series are deep, well-drained, nearly level to gently rolling soil on glacial till plains. Typically, Thoeny soils are light brownish-gray loam. The mapping symbols that indicate thoeny soils are located in groups III and IV. Permeability is slow in these soils. All features are favorable for pond and reservoir use. Severe limitations occur when used as sewage disposal. These soils contain 8 inches of good topsoil that produce a moderate harvest of wheat and barley. Native grasses include western and thickspike wheatgrass, green needlegrass, sinterfat, short-awn porcupine grass, needleandthread, and blue grama.

18. Tinsely

The Tinsley Series are deep, well-drained, strongly sloping and moderately steep soils on glaciated uplands. Typically, Tinsely soils are brown, gravelly loam surfaces and subsoils with very gravelly loamy sand underlying material. The mapping symbol that indicates Tinsely soils is in group VI. These soils flood regularly during April, May, and June. Selected use is limited because of the flooding characteristic of these soils. Native grasses include green needlegrass, western wheatgrass, snowberry, and rosebush. This soil is suitable for rangeland.

19. Vanda

The Vanda Series are deep, well-drained, nearly level and gently sloping soils on alluvial fans and terraces. They are dispersed clayey soils affected with sodium. Typically, Vanda soils are light brownish-gray silty clay. The mapping symbols that indicate Vanda soils are located in group VI and VII. The slow permeability noted in these soils allows pond and reservoir implacements. The poor topsoils permit use mainly as rangeland. Native grasses include western wheatgrass, plains reedgrass, sandberg bluegrass, squirreltail and big sagebrush."

E-5.2--ATMOSPHERIC-RELATED CHARACTERISTICS

E-5.2.1 Glasgow Meteorology and Air Quality Analysis Report

A. Introduction

In September 1977, the Montana Energy and MHD Research and Development Institute (MERDI) installed a 100-meter meteorological tower at Glasgow Air Force Base (GAFB), Montana. The purpose of the tower was to establish the solar and wind energy potential and the atmospheric dispersion potential of that northeastern Montana area. The tower was equipped with sensors at three levels: 10 meters, 31.6 meters, and 100 meters. The tower was located at GAFB, about 20 miles north of Glasgow, Montana, at an elevation of 827 meters.

This report presents wind energy, solar energy, and pollution dispersion data obtained from the GAFB meteorological tower between October 25, 1977 and August 31, 1978, as well as background meteorological and air quality data. In addition, it compares data collected from GAFB with data obtained from the Glasgow National Weather Service (NWS) between October 25, 1977 and June 30, 1978. Data collected during this time period is also compared with historical Glasgow NWS data.

B. Wind Speed Characteristics

One possible re-use for the air base is an electrical generation center utilizing wind-powered generators. Therefore, it is necessary to establish average wind speeds, most frequently observed wind speeds, and other statistics to determine the feasibility of wind-powered electricity generation.

1. Monthly Wind Speed Averages

Wind speeds at the 10-meter level averaged 5.1 meters per second (ms^{-1}) in April. Monthly wind speed standard deviations were generally between 2 and 3 ms^{-1}, implying high monthly variability. An average wind speed of 6.2 ms^{-1} was observed at the 31.6 meter level; monthly speed averages ranged from 5.2 ms^{-1} in March to 8.2 ms^{-1} in April, showing the same monthly variability observed at the 10-meter level. The average wind speed at the 100-meter level was 7.8 ms^{-1}, with monthly averages ranging from 6.7 ms^{-1} in June to 9.7 ms^{-1} in April. Note that wind speeds at all three levels show the same month-to-month trends;

wind speeds decrease markedly during the summer months. Monthly speed standard deviations increase somewhat with height, indicating higher wind speed variability at the higher levels.

Day-to-day wind speed variability is even more pronounced. Note that during November, daily wind speed averages at the 10-meter level ranged from 1.3 ms^{-1} on November 28 to 9.7 ms^{-1} on November 2. Daily wind speed variability also varies considerably with standard deviations ranging from 0.9 ms^{-1} on November 18 to 4.8 ms^{-1} on November 26. This indicates fairly constant winds on some days and highly variable winds on others.

2. Distribution of Wind Speeds

Average wind speeds give an indication of the available wind power in an area; however, that information alone is insufficient. In wind energy determinations, it also is important to know which wind speeds are most common (i.e., which speeds will supply most of the wind power). Speeds between 3 and 4 ms^{-1} were the most common while each 1 ms^{-1} speed interval between 2 and 6 ms^{-1} accounted for over ten percent of the observations. Note that the most frequently observed speed intervals are below the average speed of 5.1 ms^{-1}, indicating that this average resulted from many winds just below the average speed and a scattering of winds above that speed.

At the 3.16-meter level, the average speed was 6.2 ms^{-1}. Note that each 1 ms^{-1} speed interval between 3 and 7 ms^{-1} accounted for over ten percent of the observations, while speeds between 5 and 6 ms^{-1} were most common. This suggests that speeds at 31.6 meters tend to be more centered about the average than speeds at the 10-meter level and that the most common speeds are closer to average. A greater variety of wind speeds was observed at 31.6 meters than at 10 meters.

At the 100-meter level, the average speed was 7.8 ms^{-1}. Wind speeds between 6 and 7 ms^{-1} were most common; however, these accounted for only ten percent of the observations. This distribution closely approximates a normal distribution centered about the average, unlike the 10-meter and 3.16-meter distributions. There are higher wind speed variations at the 100-meter level; wind speeds are not concentrated within a few ranges, as at the 10- and 31.6-meter levels.

C. Glasgow Temperature Characteristics

The climate of the Glasgow area is characterized by large seasonal temperature variations, as well as high day-to-day temperature variability. Table E-5.2.1.1 indicates monthly temperature averages ranging from -18.7°C in January to 20.7°C in July. Diurnal ranges are usually moderate; average diurnal ranges varied from 5.6°C in February to 10.8°C in June although a range of 15°C or more was observed at least once in most months. High monthly variations in temperature were common; in March, for example, temperatures ranged from - 26.5°C to 17.8°C.

A comparison of average temperatures at GAFB and Glasgow NWS reveals great similarity; monthly temperature averages at the two locations never differed by more than 1.4°C. Overall temperature averages during the study period were 2.6°C at Glasgow NWS and 2.5°C at GAFB.

A comparison of Glasgow NWS monthly temperature averages during this study period with normal monthly temperature averages shows that the winter of 1977-78 was much colder than normal. Temperatures averaged 6.2° below normal in January, 4.9° below normal in December, and 4.4°C below normal in February. Slightly above normal temperatures were recorded in April, May and June.

A very important wintertime consideration is the wind chill factor. The wind chill factor is the still air temperature that would have the same cooling effect on exposed human flesh at a given combination of temperature and wind speed. The wind chill effect is more pronounced at lower temperatures; in October, for example, the average temperature was 8.2°C and the average wind chill temperature was 2°C. In January, however, the average temperature was -18.7°C, while the average wind chill temperature was -32°C. Wind chill temperatures averaged about 20°C colder than ambient temperatures in December, January, and February, and about 10°C colder than ambient in other months. These

Table E-5.2.1.1--Glasgow Temperature Data (all values are in °C)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG
AVERAGE TEMPERATURE	8.2	-3.9	-13.1	-18.7	-13.6	-4.1	5.2	12.0	16.4	20.7	18.9
AVERAGE MAXIMUM TEMPERATURE	12.5	0.3	9.8	-15.3	-10.8	-0.7	9.5	16.7	21.8	25.6	24.8
AVERAGE MINIMUM TEMPERATURE	3.9	-8.2	-16.4	-22.1	-16.4	-7.6	0.8	7.2	11.0	15.7	13.0
GREATEST DIURNAL RANGE	15.0	15.0	22.8	20.2	10.8	13.3	16.7	18.8	14.9	16.1	16.5
HIGHEST TEMPERATURE	16.2	14.4	5.5	-3.5	2.4	17.8	18.0	31.0	28.1	33.1	33.4
LOWEST TEMPERATURE	-0.2	-20.0	-36.6	-28.4	-25.5	-26.5	-4.4	3.2	4.2	10.5	4.0
AVERAGE GLASGOW NWS TEMPERATURE	7.8	-4.2	-13.2	-18.9	-13.7	-4.2	6.6	12.7	17.1	19.5	18.8
NORMAL GLASGOW NWS TEMPERATURE	8.0	-1.7	-8.3	-12.7	-9.3	-3.8	6.0	12.3	16.7	21.4	20.6
AVERAGE WIND CHILL FACTOR	2	-13	-26	-32	-29	-12	-5	--	--	--	--

figures indicate that, during winter months, the wind chill effect is a very important consideration for human comfort in the Glasgow area.

D. Solar Energy Characteristics

Another possible re-use for GAFB is a solar energy production center. To assess the feasibility of this alternative, it is necessary to examine the seasonal and diurnal variations in incoming solar radiation. Solar data was collected with a normal incidence pyrheliometer, as well as a precision spectral pyranometer. Data collected by these instruments were then reduced by computer to yield monthly hourly averages of direct beam normal incidence and diffuse solar radiation; the results are presented in Tables E-5.2.1.2 and E-5.2.1.3.

From Table E-5.2.1.2 it is evident that direct beam normal incidence solar radiation shows a strong seasonal dependence. Direct beam normal incidence solar radiation is highest during the summer months and lowest in winter. From October through April the highest values generally occur near the time of solar noon. During May, June, and August, however, the highest values usually occur one or two hours before noon. This may occur because mornings during late spring and summer are generally clear, while an increase in cloudiness due to cumulus cloud buildups often occurs around mid-day during late spring and summer. The highest average direct beam normal incidence solar radiation, .87 Langleys per minute (Ly/min), was observed in August at 1000 MST. In April, however, the highest hourly average was only 137 Ly/min., observed at 1200 MST.

Table E-5.2.1.3 shows that diffuse radiation values are lower than direct beam normal incidence radiation values during all months except February and April--this difference is most pronounced during the summer. Diffuse radiation values are lowest in fall and early winter and highest in spring. Diffuse radiation values are usually highest around mid-day. Highest mid-day averages ranged from .19 Ly/min. in November to .53 Ly/min. in June (the value of .50 Ly/min. observed in March represents only half a month of data).

E. Glasgow Precipitation Characteristics

Table E-5.2.1.4 shows precipitation data from GAFB and Glasgow NWS. GAFB precipitation data is inaccurate from November through March; precipitation during this period usually falls as snow, and the water content of frozen precipitation was not measured accurately by the tipping bucket rain guage at GAFB. During other months when precipitation fell mainly as rain, 255.77 mm of

Table E-5.2.1.2--Monthly Hourly Averages of Direct Beam Normal Indicence Solar Radiation (all values are in Langleys/min)

HOUR	OCT*	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
0500	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.03	0.11	0.06	0.01
0600	0.00	0.00	0.00	0.00	0.00	NA	0.02	0.24	0.33	0.40	0.27
0700	0.00	0.00	0.00	0.00	0.00	NA	0.09	0.38	0.41	0.59	0.53
0800	0.08	0.09	0.00	0.00	0.05	NA	0.18	0.52	0.54	0.69	0.78
0900	0.15	0.37	0.11	0.13	0.14	NA	0.26	0.60	0.65	0.67	0.84
1000	0.21	0.46	0.24	0.25	0.15	NA	0.33	0.69	0.68	0.61	0.87
1100	0.32	0.57	0.34	0.32	0.21	NA	0.34	0.68	0.67	0.62	0.86
1200	0.52	0.65	0.38	0.35	0.26	NA	0.37	0.63	0.63	0.66	0.84
1300	0.64	0.64	0.33	0.38	0.29	NA	0.35	0.55	0.61	0.72	0.79
1400	0.56	0.62	0.30	0.34	0.40	NA	0.33	0.60	0.63	0.81	0.76
1500	0.50	0.52	0.27	0.31	0.38	NA	0.26	0.60	0.50	0.80	0.77
1600	0.46	0.32	0.17	0.24	0.34	NA	0.14	0.50	0.39	0.76	0.72
1700	0.18	0.04	0.00	0.04	0.21	NA	0.06	0.38	0.42	0.78	0.77
1800	0.00	0.00	0.00	0.00	0.04	NA	0.01	0.24	0.41	0.65	0.60
1900	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.11	0.23	0.50	0.33
2000	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.01	0.07	0.12	0.04
2100	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00
2200	0.00	0.00	0.00	0.00	0.00	NA	0.00	0.00	0.00	0.00	0.00

NA = Not available due to loss of data.

* = Averages are based on partial data base.

Table E-5.2.1.3--Monthly Hourly Averages of Diffuse Solar Radiation (all values are in Langleys/min)

HOUR	OCT*	NOV	DEC	JAN	FEB	MAR*	APR	MAY	JUN	JUL	AUG
0500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.01
0600	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.11	0.07	0.04
0700	0.01	0.00	0.00	0.00	0.00	0.01	0.10	0.09	0.20	0.12	0.09
0800	0.06	0.03	0.00	0.00	0.04	0.04	0.20	0.15	0.29	0.15	0.15
0900	0.17	0.10	0.06	0.05	0.16	0.23	0.29	0.21	0.35	0.23	0.21
1000	0.26	0.15	0.13	0.14	0.29	0.07	0.35	0.28	0.39	0.31	0.26
1100	0.31	0.18	0.19	0.21	0.39	0.23	0.39	0.32	0.47	0.34	0.32
1200	0.28	0.18	0.21	0.27	0.48	0.54	0.43	0.39	0.53	0.36	0.34
1300	0.23	0.19	0.23	0.30	0.46	0.57	0.39	0.41	0.50	0.35	0.35
1400	0.16	0.16	0.19	0.26	0.40	0.58	0.39	0.42	0.38	0.26	0.32
1500	0.13	0.11	0.12	0.16	0.31	0.49	0.37	0.34	0.39	0.28	0.28
1600	0.09	0.06	0.04	0.07	0.20	0.33	0.30	0.27	0.37	0.24	0.24
1700	0.03	0.01	0.00	0.01	0.08	0.27	0.25	0.23	0.27	0.21	0.17
1800	0.00	0.00	0.00	0.00	0.01	0.10	0.14	0.16	0.18	0.12	0.10
1900	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.08	0.12	0.10	0.05
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.04	0.01
2100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

* = Averages are based on partial data base.

Table E-5.2.1.4--Glasgow Precipitation Data (all values are in mm)

	OCT	NOV*	DEC*	JAN*	FEB*	MAR*	APR	MAY	JUN	JUL	AUG
TOTAL PRECIPITATION	8.13	1.52	4.83	1.02	7.11	0.00	8.13	98.04	99.06	28.19	3.30
MAXIMUM 1-HOUR TOTAL	4.32	0.51	0.76	0.76	4.57	0.00	1.27	7.11	10.41	9.14	1.02
MAXIMUM 3-HOUR TOTAL	7.37	0.76	1.02	0.76	4.57	0.00	2.29	14.48	18.80	14.99	1.27
MAXIMUM DAILY TOTAL	8.13	0.76	2.03	0.76	4.57	0.00	3.81	34.54	27.43	15.49	1.27
TOTAL GLASGOW NWS PRECIPITATION	10.16	6.10	21.84	4.83	10.16	6.35	12.95	92.71	69.09	66.80	4.06
MEAN GLASGOW NWS PRECIPITATION	14.22	9.91	7.87	9.91	8.13	9.40	18.03	33.27	69.09	36.32	38.35
TOTAL EVAPORATION								137.16	175.77		

* Glasgow AFB precipitation totals are incorrect during these months because the tipping bucket rain gauge does not correctly measure the water content of frozen precipitation. Most precipitation during these months falls as snow.

precipitation fell at Glasgow NWS while 244.85 mm fell at GAFB. These values are very similar for two stations located 20 miles apart. High inter-station variability was observed during individual months; however, in June, for example, 99.06 mm of precipitation fell at GAFB while Glasgow NWS recorded only 69.09 mm. Conversely, in July GAFB had 28.19 mm of precipitation while Glasgow NWS had 66.80 mm. These differences appear to balance out over long periods of time.

The heaviest precipitation, as well as the greatest precipitation intensities, occurred in the spring at GAFB. A one-day total of 34.54 mm was observed in May; one-hour and three-hour total of 10.41 mm and 18.80 mm were observed in June.

A comparision of monthly Glasgow NWS precipitation totals with Glasgow NWS mean monthly totals show that this study period was slightly wetter than average; 305.05 mm of precipitation fell, compared to a normal of 254.5 mm. May and July were especially wet months. This implies that GAFB precipitation may have been slightly greater than normal.

Humidity at Glasgow varies considerably during the year. During winter months humidity averages near 70 percent; mornings are slightly more humid than afternoons. During the remainder of the year humidity averages near 75 percent during morning hours and near 65 percent during evening hours. Afternoon hours show considerable seasonal variation; however, humidities of 30 to 40 percent are common in August, the least humid month. Afternoon humidities are commonly 45 to 55 percent in spring and 40 to 50 percent in fall. Of course, humidity during any time of year can vary considerably depending on the types of weather patterns that exist over the area.

F. Barometric Pressure Characteristics

Table E-5.2.1.5 shows GAFB barometric pressure data. The lowest pressure average, 910.6 millibars (mb), occurred in April; this was probably associated with the frequent passages of low pressure systems during that time of year. The highest pressure average, 917.0 mg,occurred in January; this was probably due to the prolonged presence of polar anticyclones over the area.

The fraction of all pressure observations within each 10 mb pressure interval also is given. During December barometric pressures within all intervals were observed while in some months pressures within only three

Table E-5.2.1.5--Glasgow AFB Barometric Pressure Data
(all values are in mm)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG
AVERAGE BAROMETRIC PRESSURE	910.7	915.7	913.2	918.0	915.9	913.3	910.6	911.4	913.4	914.0	913.9
STANDARD DEVIATION	6.3	3.4	7.6	3.7	2.2	1.8	2.3	1.0	3.7	7.6	2.3
PERCENT OF OBSERVATIONS BETWEEN:											
890-900 MB	0.0	1.8	4.4	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0
900-910 MB	42.2	15.9	40.1	13.9	15.3	33.6	37.8	39.1	24.5	21.8	26.5
910-920 MB	57.8	56.1	29.3	47.7	64.6	52.2	54.7	52.7	67.7	60.8	57.9
920-930 MB	0.0	26.3	21.6	34.5	17.5	14.1	3.1	8.2	7.9	17.4	15.6
930-940 MB	0.0	0.0	4.6	3.8	2.6	0.0	0.0	0.0	0.0	0.0	0.0

of the intervals were observed. This indicates fairly consistent barometric pressures in some months and highly variable pressures in other months (e.g., December). The highest pressures tend to occur in winter months, while the lowest pressures occurred in spring. The pressure at GAFB is normally 20 mb lower than the pressure at Glasgow NWS due to an elevation difference. GAFB is at an elevation of 827 meters while Glasgow NWS is at an elevation of 696 meters.

G. Air Quality of the Glasgow Air Force Base

In association with the meteorological monitoring at GAFB, MERDI collected air quality data from January through August 1978. This information delineates the current air quality of the region and provides a base for projecting the resultant impacts of future developments in the area on air quality.

MERDI's air quality program consisted of collecting 24-hour high-volume air samples every third day and setting out a dustfall jar and static samples (sulfation plate, nitration plate, and fluoridation plate) for a month at a time. The high-volume samples and dustfall jars were analyzed for total particulates and 28 trace elements (see Table E-5.2.1.6).

A high-volume air sampler consists of a vacuum motor which draws ambient air through a filter at a known rate. It measures the total amount of suspended dust in the air. Four parameters have federal and/or state of Montana standards. These are total particulates, berrylium, lead, and sulfate. In no case did any measured value of any parameter exceed the appropriate standard, and usually was considerably less than the standard.

The dustfall collector is simply an inert plastic jar, partially filled with water or a water/alcohol mixture, which collects the settleable particulates in the air. It is set out for a month at a time. In one instance, January 1978, the amount of dust collected exceeded the standard for residential areas. The standard is based upon a three-month average; however, no three-month averages of the measured values exceeded the standard.

Static samplers are media which are chemically treated to react with a given pollutant. They are exposed to the ambient air for a month and then analyzed. In no case did the measured value of a sampler exceed the appropriate standard; values, in fact, averaged a factor of ten below the standards.

Table E-5.2.1.6--Trace Elements Analyzed in High-Volume and Dustfall Samples

Aluminum (Al)
Arsenic (As)
Boron (B)
Beryllium (Be)
Benzene Solubles (Ben Sol)
Bismuth (Bi)
Calcium (Ca)
Cadmium (Cd)
Chlorine (Cl)
Cobalt (Co)
Chromium (Cr)
Copper (Cu)
Fluorine (F)
Iron (Fe)
Mercury (Hg)
Potassium (K)
Magnesium (Mg)
Manganese (Mn)
Molybdenum (Mo)
Sodium (Na)
Nickel (Ni)
Lead (Pb)
Antimony (Sb)
Selenium (Se)
Tin (Sn)
Sulfate (SO_4)
Vanadium (V)
Zinc (Zn)

E-5.2.2 Communications Quality Measurements

On May 11 and 12, 1978 the communication quality was checked at three locations in or near Glasgow, Montana; it was checked at a location between the Glasgow Air Force Base and Glasgow; and it was checked at five locations in and around the Air Force base. The results were not unexpected. That is, generally the radio frequency noise was very low, the local AM radio station signal level was high throughout the area, and the TV signal levels were moderately high in Glasgow, coming from a nearby repeater, but were virtually nonexistant at the ranches near the Air Force base. The AM and TV signal levels in the Glasgow community are sufficiently high in amplitude so that additional radio and TV noise can be tolerated without degradation to the communication systems. The Air Force base and the area around the base are so far from any commercial sources of communication signals that signals of this type are so low (and the noise is also low) that any new radio or TV noise will be both apparent and will cause degradation. There are some areas near the Air Force base where there may be no reasonable TV reception now so there is no signal quality to protect (from noise).

Each site tested will be considered separately in the report that follows. The present quality of the AM, FM and TV channels will be presented and compared to measurements made at other similar locations. The likely effects of a new source of radio frequency interference (RFI) on each communication system will be presented. These considerations will also include electromagnetic propagation characteristics, possible RFI source characteristics, and the potential degradation to commercial communication systems. The audio levels measured will be presented.

Some of the data presented and discussed in the following sections of this report are presented in Table E-5.2.2.1 for comparisons. All numbers are in dB relative to 1 volt into the receiver.

In the "AM radio station level" section 540 kHz, 690 kHz and 1,440 kHz are from nearby communities. The 690 kHz signal is from a French Canadian station. The 1,240 hKz signal is from a Glasgow radio station.

When a TV signal level is not shown it generally means that the signal was not detected at that location.

A question mark for a noise source indicates the source of the noise was not identifiable.

TABLE E - 5.2.2.1

Site		1	2	3	4	5	6	7	8	9
AM radio station levels	540 kHz	26	18	24	28	27	26	27	30	30
	690 kHz	24	28	29	27	31	28	19	34	29
	1,240 kHz	60	64	66	43	40	46	40	39	43
	1,440 kHz	19	16	22	21	-	20	17	-	25
AM band quasi-peak noise level	834 kHz	-15	-13	-14	-14	-8	-13	-14	-13	-15
Lower VHF TV noise reference	75 MHz	15	34	12	18	10	10	10	35	10
Noise source at 75 MHz		transformer	transformer	transformer	transformer	galactic	galactic	transformer	metal Shed	galactic
Glasgow FM station level	104 MHz	31	21	55	23	8	5	7	0-10	-
FM noise reference	100 MHz	20	35	11	13	7	15	11	25	8
Higher VHF TV signal levels	Channel 7,174 MHz	40	55	46	16	13				
	Channel 9,186 MHz	47	57	57	21					
	Channel 11,198 MHz	40	42	43	11		(not observed)			
	Channel 13,210 MHz	27	39	37	14					
Higher VHF TV noise reference	150 MHz	15	18	8	17	8	9	8	30	7
Noise level (above VHF TV band)	250 MHz	18	13	12	24	12	30	16	15	11
250 MHz noise source		?	transformer	Receiver	transformer	Receiver	transformer	?	?	Receiver
600 MHz noise	600 MHz	15	15	15	22	15	28	15	15	15

TABLE E - 5.2.2.1, cont.

Site	1	2	3	4	5	6	7	8	9
UHF TV signal levels									
820 MHz			30	46					
835 MHz			33	43	(not observable)				
845 MHz			31	41					
860 MHz			27	40					
800 MHz noise	15	15	18	17	15	26	16	16	15

Site #1, South Side School in Glasgow

On May 12, 1978 at 1830 MDT the WTC test crew recorded the electromagnetic signal and noise levels at the South Side School in Glasgow, Montana. See map A-1 in the appendix. The radio frequency interference (RFI) in the AM band was very low. Note the location of the 834 kHz quasi-peak noise level at site #1 on Figure E-5.2.2.1. Figure E-5.2.2.1 is a histogram showing the level of the 834 kHz quasi-peak noise recorded at approximately 200 rural residences. The usual source of this noise is distribution line transformers. With the many transformers in a town, the site #1 low AM band noise is somewhat surprising.

The local AM radio station is very strong at site #1. The quality of the channel is basically perfect (high signal-low noise). The quality would still be excellent if the noise level were increased by a multiplicative 10,000. There are, however, a variety of other AM stations received at Glasgow from neighboring communities that have marginal signal levels. With the low noise level at site #1 these stations can be received with very good quality. Additional noise will degrade these stations. If the AM band noise were increased by 10,000 these AM channels would be unusable.

The 75 MHz peak noise, used as the noise reference for the low-band (channels 2-6) TV, was relatively low at site #1. Note the location of the site #1 75 MHz peak noise on Figure E-5.2.2.2. Figure E-5.2.2.2 is a histogram similar to Figure E-5.2.2.1 except for a change in frequency. There were, however, no low-band TV signals recorded at site #1. The noise source was a nearby transformer.

Four high-band TV signals were recorded at site #1 between the frequencies of 174 MHz and 210 MHz. These signals received over a high-band TV antenna would produce excellent quality considering the noise level recorded. Note where site #1 is located on Figure E-5.2.2.3. Figure E-5.2.2.3 is a histogram of the best TV signal-to-noise ratio, (in dB), recorded at the 200 rural residences. Also shown on Figure E-5.2.2.3 is the quality of the TV picture as a function of the signal-to-noise ratio (S/N). It is true that the neighbors to site #1 have excellent TV. The noise level in the high-band TV region is low at site #1 at 15 dB. If the noise level is increased and is located such that the antenna cannot eliminate it, it will degrade the picture if the noise increases by 100 times. This degradation will be in the form of "snow" on the screen.

The local FM station was recorded at 31 dB while the peak noise measurement for the FM band at 100 MHz was 20 dB. This channel will not produce excellent FM.

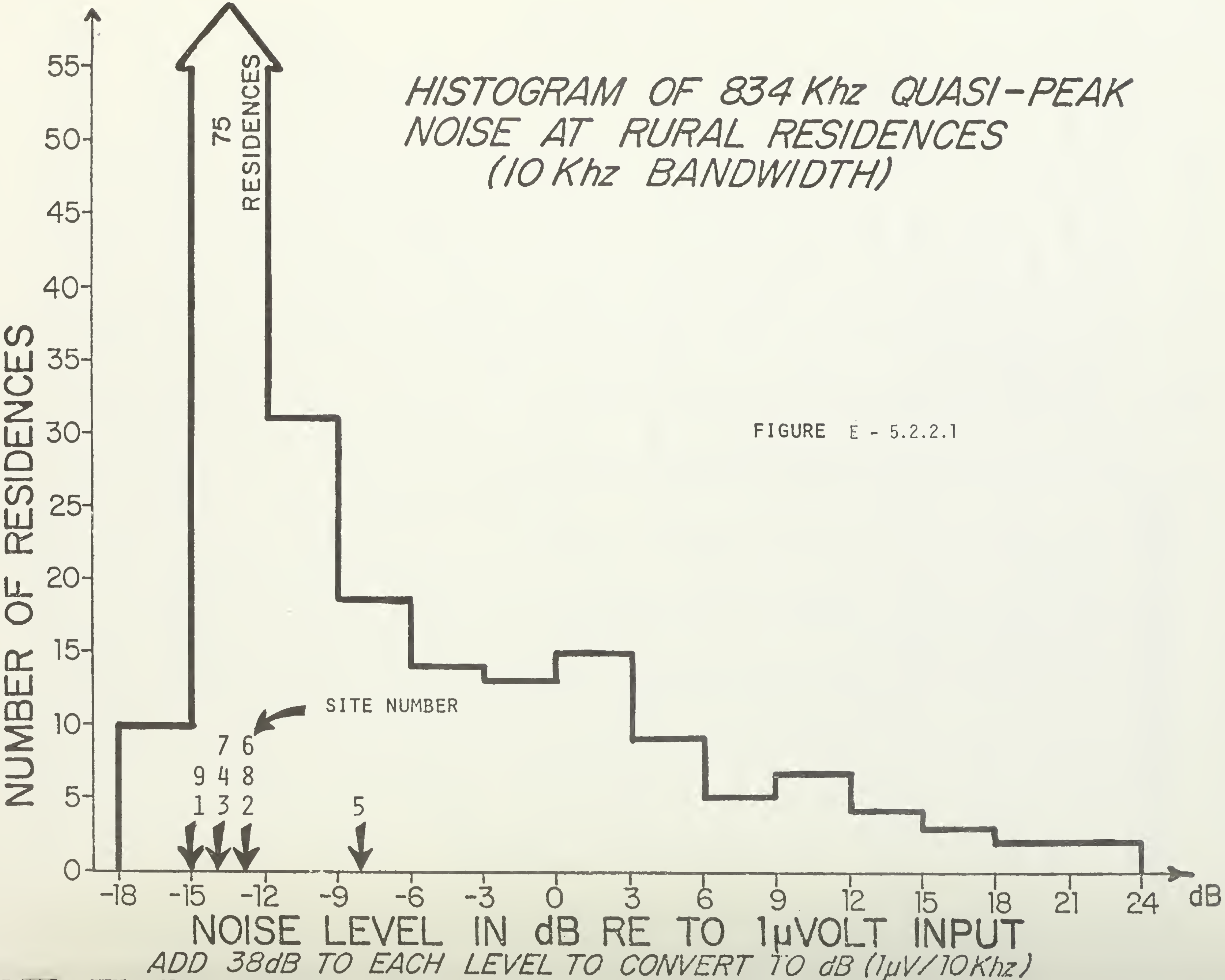
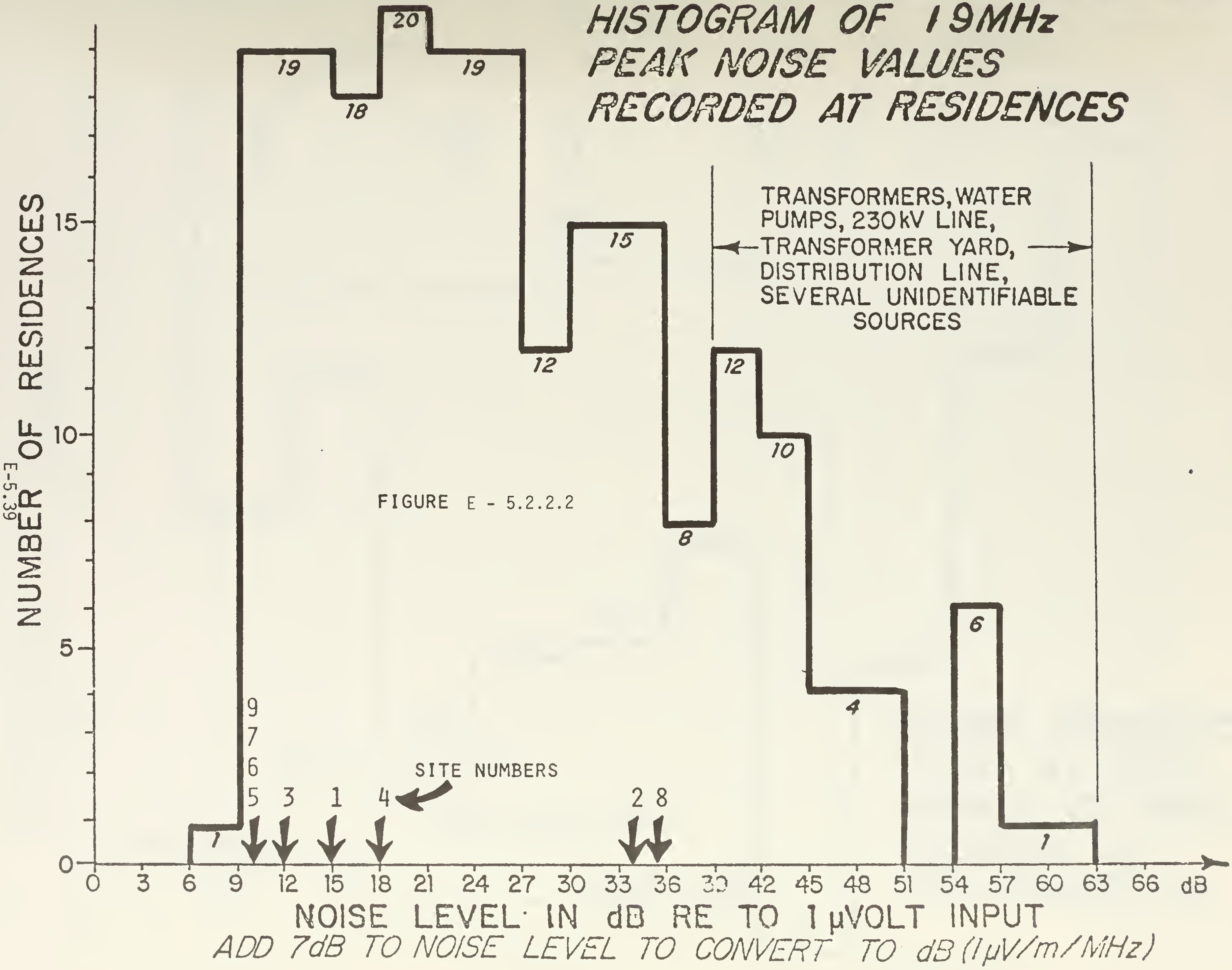


FIGURE E - 5.2.2.1



HISTOGRAM OF 19MHz PEAK NOISE VALUES RECORDED AT RESIDENCES

FIGURE E - 5.2.2.2

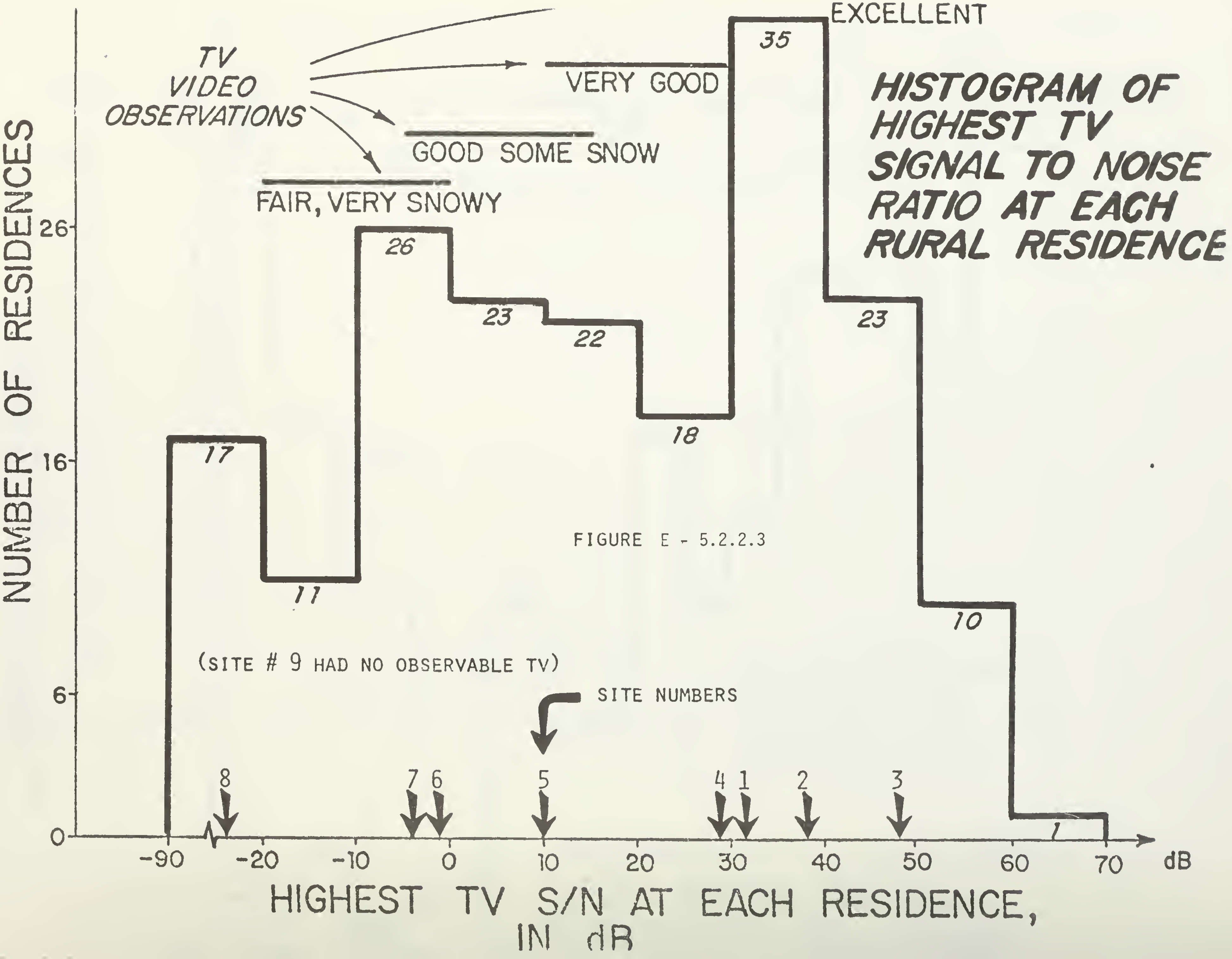
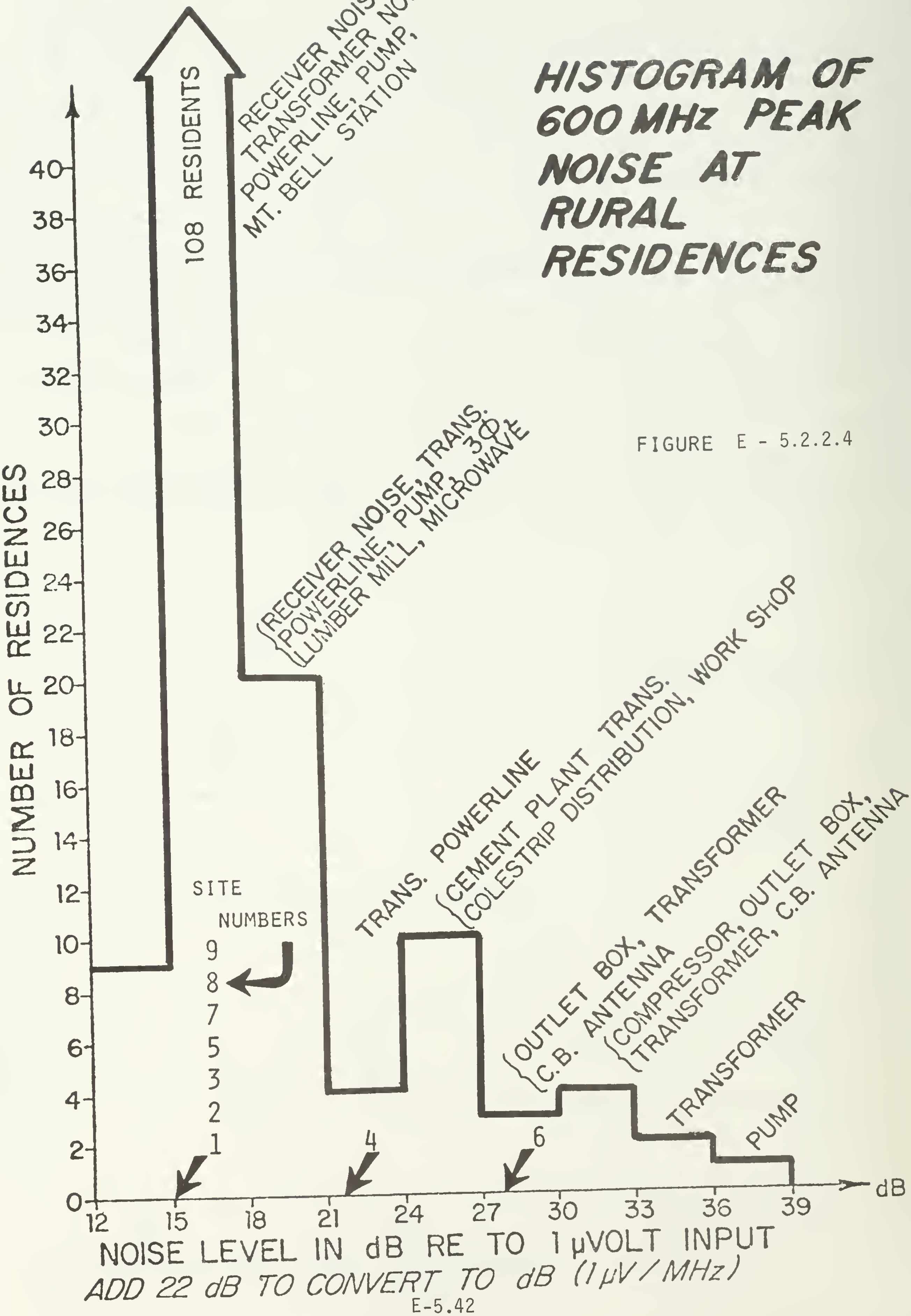


FIGURE E - 5.2.2.3

HISTOGRAM OF HIGHEST TV SIGNAL TO NOISE RATIO AT EACH RURAL RESIDENCE

The signal level, at 31 dB, is very low compared to the FM station signal levels recorded in the vicinity of the new MHD facility at Butte. There the FM signal levels were at 80 to 90 dB. The noise levels in Butte were higher than at site #1 but still the FM quality was better in Butte. The S/N for FM in Butte was approximately 40 dB while the S/N in Glasgow was approximately 10 dB. The higher the S/N, the better the communication quality. Figure E-5.2.2.4 shows a histogram of the 600 MHz peak noise received at approximately 200 residences. At most locations the noise source was the receiver itself. An obvious source was generally apparent at those locations where the local noise exceeded the receiver noise. Examples of these noise sources are shown on the histogram. The site #1 600 MHz peak noise was simply receiver noise (at 15 dB). At all frequencies above approximately 400 MHz the noise observed was receiver noise.

The A scale audio measurements made at site #1 show the effects of the wind present. The two reading were 51 dBA and 48 dBA. The usual noise level at this locations would vary as the urban activity increased and as school was in session.



HISTOGRAM OF 600 MHz PEAK NOISE AT RURAL RESIDENCES

FIGURE E - 5.2.2.4

Site #2, Trailer Court

On May 11, 1978 at 1930 MDT the WTC test crew measured the communication quality at a trailer court in Glasgow, Montana. Again Figure E-5.2.2.1 shows that the AM band noise at this site was very low. The local AM radio station was received at high signal level, 64 dB. The quality would still be excellent if the noise were increased 10,000 times. The several AM signals from nearby communities were received at levels (16 to 28 dB) which could be received with very good quality,considering the low noise. However, additional noise would be apparent to a listener as static. Thus,the local station can tolerate a large increase in noise but the signals from nearby communities cannot.

The 75 MHz peak noise recorded at site #2 was moderately high. Note Figure E-5.2.2.2. The noise source was a nearby black distribution transformer. The black color shows the transformer is old. A rural residence with a black transformer usually will have a high 75 MHz peak noise and the source of the noise will be the transformer.

The broadband noise from the transformer was down by nearly 20 dB in the frequency range of the several local TV translator channels. Figure E-5.2.2.3 shows that the S/N quality of the TV was high. A 39 dB S/N will produce excellent TV. Again, the high frequency of the TV signals means that directive antennas can usually eliminate the effects of a localized new noise source. No facility at the Glasgow Air Force Base will harm the TV in Glasgow.

The FM station serving Glasgow was received at a 21 dB level, which is 10 dB lower than that received at site #1. This channel is susceptible to additional noise. The S/N was low and the effects of noise would be apparent on most simple FM receivers.

The 600 MHz peak noise was the same level at site #2 as at site #1. In both cases the source of noise was the receiver itself. The receiver noise became the predominant noise source at approximately 300 MHz.

The audio noise at the recording site was due to the nearby highway. The A scale reading of 41 and 44 dBA are due to the traffic. These levels are representative of the audio noise levels in the trailer court at that time.

Site #3, Glasgow Airport

On May 12, 1978 at 1930 MDT the WTC test crew recorded the electromagnetic signal and noise levels in the parking lot of the Glasgow Airport. The AM noise level was again very low. Note Figure E-5.2.2.1 for a general comparison. The AM radio signals received were similar to those received at the other two sites in Glasgow.

The 75 MHz peak noise level measured at the airport was expecially low, as noted in Figure E-5.2.2.2. The noise source at this frequency was a nearby transformer. An interesting comparison is between the 75 MHz peak noise at the Butte airport versus that at the Glasgow airport. On April 24, 1977, the measured value of the 75 MHz peak noise at the Butte airport was 35 dB while the recent measured value at the Glasgow airport was 12 dB (more than 100 times less). It is true that the electromagnetic noise levels in Butte are generally much higher than those in Glasgow. It is also true that the signal levels in Butte are much higher than in Glasgow. Thus a new noise source, like a MHD facility, can be tolerated in Butte much better, communication-wise, than in Glasgow.

The four TV translator signals were received with approximately the same amplitude at the airport as at each of the other sites in Glasgow. Again each channel has excellent quality. Note Figure E-5.2.2.3. At the airport the UHF TV signals (820 to 860 MHz) that feed the local translator are received with high amplitude. With a reasonable antenna, these signals would produce excellent TV video. Because of the ultra high frequency (UHF) nature of these signals, very directive antennas can be used to eliminate most noise from extraneous sources. Also, at 800 MHz the attenuation of a radio noise with distance is very great. A facility at the Glasgow Air Force Base should not harm the Glasgow TV translator receiving system (at 820 to 860 MHz). If an Air Force base problem did exist, it could be identified and eliminated.

The 600 MHz peak noise, see Figure E-5.2.2.4 at the airport was due to internal receiver noise. The internal receiver noise became the primary noise source at a relatively low frequency of 300 MHz. This again demonstrates the low noise that was measured.

The audio measurements made at the airport parking lot are meaningless as they simply show the meters response to the 20 MPH wind.

Site #4, Trailer Court, 6 miles south of Glasgow Air Force Base

The electromagnetic signal and noise levels were measured at this site at 1640 MDT on May 12, 1978. The AM band noise was low, note Figure E-5.2.2.1. The AM signal from the Glasgow radio station was down by approximately 20 dB relative to the signal level in Glasgow. However,the S/N of 57 dB still produces excellent AM radio. Further, some additional RFI can be tolerated before degradation occurs. The AM signals from the nearby communities were approximately the same level here as in Glasgow. Additional noise will degrade these communication systems.

The 75 MHz peak noise recorded at this site was higher than at the airport site but at 18 dB was still relatively low. Note Figure E-5.2.2.2. The noise source was a nearby transformer. No TV signals were observed in the low-band VHF TV spectrum. The upper-band VHF TV signals from the Glasgow translator were recorded at levels from 11 to 21 dB. The peak noise levels recorded in this part of the spectrum varied from 17 to 24 dB. Thus,the average S/N was approximately 0 dB. Note Figure E-5.2.2.3. A typical rural TV system set up where the measurements were made would probably have good quality,but some"snow" would be apparent. The several mobile homes at the court do not have "excellent" TV from these signals. Any significant additive noise will further degrade the quality. However, the site was in the signal path of the UHF signals going to the Glasgow TV translator. The signal levels of these signals (820 to 860 MHz) range from 40 to 46 dB. Then, even though the noise at this site is high due to the transformer, excellent TV could be acquired from these signals. These TV channels would be immune to additive noise unless it was very high in amplitude and this will either not happen,or is correctable if it does happen.

The Glasgow FM is received at 23 dB while the Scobey FM is received at 9 dB. Both of these communication lines are marginal and significant additive noise will degrade the quality. These two FM systems are susceptible to RFI from a noise source at the Air Force base. However, the quality can be restored, if the noise is not too severe, by using directive antennas which are fairly reasonable at 100 MHz.

Figure E-5.2.2.9 shows that the 600 MHz peak noise at this site, number 4, was relatively high. The noise source was a nearby black transformer. The received noise exceeded the receiver noise until approximately 800 MHz, again due to the noisy (electrically) transformer.

At this site the wind was blowing at 15 to 20 MPH. The audo measurements show the effects of the wind and do not indicate the general noise level. The A scale readings were 40 and 42 dBA.

Site #5, Shipp's (6 miles southwest of Glasgow Air Force Base)

On May 12, 1978 at 1330 MDT the WTC test crew made the electromagnetic signal and noise measurements at the Shipp residence. This is an isolated residence located six miles west southwest of the Glasgow Air Force Base fire station. There are no other nearby residences. The local transformer was 150 yards from the measurement site and was a relatively quiet transformer (electrical noise-wise).

The AM band noise at this location was not exceptionally low. The value of -8 dB is above average for a rural residence,as is apparent in Figure E-5.2.2.1. The Glasgow AM radio signal, at 40 dB, is sufficient to produce excellent AM quality. A French Canadian station, at 31 dB, also can produce excellent quality. Significant additive noise will degrade these channels. An RFI noisy transformer near the Shipp house would probably degrade the AM stations. The French Canadian station at 690 kHz would be degraded first.

The 75 MHz peak noise at this location was 10 dB which is among the quietest locations checked by the WTC crew. Note Figure E-5.2.2.2. No noise was apparent. The noise present was then galactic noise.

The TV signals from the Glasgow translator were not high in amplitude at the Shipp location. From the plots made at the recording site the TV S/N varies between 5 and 10 dB for the four TV channels. The residence had a directional antenna on a 30-foot tower. The TV quality, in judging from Figure E-5.2.2.3, was good with some"snow"to very good. Significant additive noise will degrade all of the channels. However, the directional antenna should give good rejection (by 10 to 15 dB) of noise coming from the Air Force base. The direction to Glasgow from the Shipp residence, relative to the direction to the Air Force base, is fortuitous.

The signal from the FM station in Glasgow was received at an 8 dB level. The 100 MHz peak noise level at 1 MHz band-width was 7 dB when measured vertically. The Shipp residents probably don't listen to FM due to poor quality. An elaborate antenna system could get usable FM but the quality would be susceptible to any additional noise. The FM signal recorded probably is so low that a case can be made that it is not worth worrying about. As stated above, it is probably not used at the residence now.

The 600 MHz peak noise recorded at the Shipp residence was due to receiver noise. The receiver noise was the predominant noise for all frequencies above 200 MHz. The RFI at this site was exceedingly low. The average VHF (30 to 300

MHz) noise is approximately 30 dB less (one-one thousandsths) of the average noise level in and around Butte.

The audio measurements made at this location show only the effects of the wind.

Site #6, Abandoned Jr. High School at Glasgow Air Force Base

On May 12, 1978 at 1000 MDT the WTC test crew measured the electromagnetic communication quality at the abandoned Junior High School at the Glasgow Air Force Base. The AM noise level, at 834 kHz, was low at -13 dB. Note Figure E-5.2.2.1 for a comparison. The AM signals from nearby communities were present with moderate amplitude (21 to 31 dB). These stations can be received with very good quality at the Junior High School. The signal to noise ratio, however, were low enough that significant amounts of new additive noise will degrade the communications. The Glasgow AM radio station was received with a higher amplitude, 46 dB, and will not be degraded with additional noise unless the additional noise increases the background noise by at least 20 to 30 dB. This is unlikely as most noise sources don't have efficient antenna configurations at the AM radio frequencies. Thus, even in Butte, the highest noise level observed at 834 kHz was -3 dB which is only 10 dB higher than at the school at the Glasgow Air Force Base. Another comparative example is the data from Colstrip. During construction of Colstrip generating plants 1 and 2,the 834 kHz noise was at 13 dB. During the construction phase the radio frequency interference in Colstrip was the highest the WTC crew has measured to date. After Colstrip 1 and 2 became operational, the 934 kHz noise was recorded at 5 dB at a site one quarter mile away. The general conclusion is that the AM band noise is not likely to increase so much that the Glasgow AM radio station signal is significantly degraded at the air base, except possibly within a block or two of the new "noisy" facility. The signals from other nearby communities can tolerate less new noise, but they too should not be harmed at half a mile distance from a new facility.

The RFI measured at the school in the lower VHF part of the spectrum (30 to 150 MHz) was relatively very low. This frequency range is the range that tends to increase with industrial activity. This has been true of Colstrip and of other industrial areas sampled by the WTC test crew. In this frequency range are the TV channels 2 to 6, inclusive, and the FM bands. Judging from past data a 1000 times increase in the noise in this range is likely to occur within a mile or two of a new facility. At the air base school two low-band TV signals were observed. However, they were so low in amplitude that very good TV would be difficult to acquire. A 1000 times (30 dB) increase in the noise will destroy this TV. In fact, any significant added noise will produce additional"snow"on the video picture. Thus,this antenna receiving TV at the air base is likely to be degraded by any significant new industrial activity. However, this is not as bad a problem as it appears. The Glasgow AFB has cable TV available with five channels. Any serious TV watchers would use cable with five channels rather than the marginal two channel antenna TV. Thus, the two low-band VHF TV channels are not important to the air base community and their preservation with a low noise environment is not important. The problem is more apparent than real.

The FM radio band from 88 to 108 MHz also is likely to have a significant amount of new noise if a power generating system is installed at the air base. The two FM signals, which are really the same station, are low in amplitude and hence susceptible to additional noise. Their amplitudes are so low, 5 dB, that few people at the base probably listen to FM. The quality is so poor that there is little to protect. To get adequate FM a nearby translator is needed. Then the signal level could be increased in the air base area to provide excellent quality FM, even with a high noise environment.

The electromagnetic noise in the frequency range from 150 to 1000 MHz was high at the school. The noise source was transformer 100 yards away. Even at 1000 MHz this noise exceeded the receiver noise. For the overall air base communication quality, this noisy transformer is insignificant as it can be replaced. However, there were no general audience communication systems found in the frequency range 150 to 1000 MHz. Thus, a significant increase in the RFI in this frequency range will not interfere with any public communication systems. There may be private or governmental communication systems in this frequency range. An investigation of these systems is beyond the scope of this report. Generally these systems have to be dealt with individually. For example, the Colstrip deputy sheriff had to relocate his transceiver antenna during (and after) construction of Colstrip 1 and 2.

The audio readings at this location show the effects of a 20 to 30 mph wind.

Site #7, Meteorlogical Station

On May 12, 1978 at 0830 MDT the electromagnetic signals and noise levels were recorded at the meteorological station site at the Glasgow Air Force Base The AM band noise was low at this site. See Figure E-5.2.2.1. The AM band signals were not appreciably different here than those recorded at the abandoned school. The same arguments apply here as did at the school.

A black transformer approximately 130 yards from the recording site was the source of RFI at 40 MHz; this noise was relatively low at 75 MHz. See Figure E-5.2.2.2. The noise was low throughout the remainder of the observed spectrum. At this location no TV signals were observable. The FM signals were present with approximately the same levels as at the school. The receiver noise became the predominant noise source near 200 MHz. Thus, the area is electromagnetically "primitive". There are few signals and the noise is relatively very low.

The audio measurements at this location were meaningless. Again, the readings simply show the effects of wind on the meter.

Site #8, Anderson residence, 2 miles north of Glasgow Air Force Base

On May 12, 1978 at 1130 MDT the WTC test crew recorded the electromagnetic signals and noise at the Anderson residence. The usual AM stations were present. The Glasgow radio station was the strongest at 39 dB but several of the nearby communities signals were increasing in amplitude (relative to those locations farther south). The Canadian station had an amplitude of 34 dB. The AM band noise was low. See Figure E-5.2.2.1. There were at least three radio stations that produced excellent AM radio and several others that were at least very good. These stations don't have an excess amount of signal, but due to the distance to the base at least three of the stations have sufficient amplitude to overcome an industrial site noise source. The other stations will probably be degraded as the noise level(s) increases.

A source of RFI was present in a nearby metal shed that significantly increased the noise from 10 to 200 MHz. Only one TV signal was observed. It was at 62 MHz and had an amplitude that varied from 3 to 12 dB. The Anderson's apparently watch TV. Their antenna is on their house (note map in original data). Their TV is marginal. The metal shed noise surely put "snow" on the picture. The shed noise appears, from the data, to be intermittant. Perhaps someone was welding or doing some other task that caused the noise. If the shed noise were eliminated, their RFI appears to be very low from 50 MHz to 1000 MHz. Any significant new RFI in the TV band will probably degrade their TV quality as the signal levels are so low.

The Anderson's had available signals from five FM stations. However none of them were high amplitude; the highest being 17 dB. A good audio signal could be derived from the radio frequency signal. However,the amplitude of all of these signals were such that additional significant noise will be apparent. There is little that can reasonably be done to protect these channels.

At about 300 MHz the receiver noise became the highest noise source, indicating a low noise level above 300 MHz. No signals were present in this frequency range.

The Anderson's are citizen band radio users. The high noise from the metal shed produced a very high noise level at the CB frequency. If the metal shed noise is persistent, the Anderson's are not getting good CB reception. If the shed noise is only occasional, then the CB is limited by the ambient noise and undesired skywave reflections. The CB channels are getting so much interference due to the ionospheric reflections (a function of the sunspot activity) that a noise source at the air base will have to be very high in amplitude to cause problems with their CB. There will probably, however, be a minimum in the sunspot activity 5 or 6 years from now which will reduce the CB interference.

The audio measurements at the Anderson's residence were corrupted by 10 to 15 MPH winds.

Site #9, Cattle Camp, 2.5 miles east southeast of Air Base

The AM band noise level at the cattle camp was very low. Note Figure E-5.2.2.1. The AM signal from Glasgow was relatively strong at 43 dB. Considerable additional noise (20 dB) can be tolerated with no noticeable degradation. The other several AM stations will be degraded with 10 dB of additive noise. Per earlier discussions, increases of the noise in the AM band of 10 dB or more are unlikely, especially if the source is 2½ miles away. AM band degradation at this location is unlikely.

The 75 MHz peak noise is very low. Note Figure E-5.2.2.2. The noise is surely galactic. In fact, no local noise sources are apparent from approximately 30 MHz and higher in frequency.

There were also no TV signals apparent at the recording site. Considerable effort would have to be expended to get a usable TV signal, such as a very high antenna or putting the antenna on a hilltop. Considering that the location is a camp, without electricity, raising the noise level in the TV band will probably not be noticed.

A very marginal FM signal was present. With the very good AM signals present it is unlikely that anyone has ever listened to FM at the location. Again, additive noise can't degrade an already unusable channel.

No other communication signals were observed at the location. If a two-way radio system is used at the cattle camp, additional noise may degrade the system performance. The noise levels measured at the cattle camp are probably the lowest non-wintertime noise levels recorded by the WRC test crew. Any significant power development at the air base will increase the noise level in much of the frequency spectrum at the cattle camp. However, chances are no-one will be aware of it.

The primary source of audio noise at this site was water running in a creek approximately 100 yards away. The A scale readings were 23 and 24 dBA. These measurements also are among the lowest recorded by the WTC test crew.

E-5.3--WATER QUALITY

E-5.3.1 Aquatic (Physical and Chemical Composition)

A. Methods

All methods used in the analysis of water and biological samples collected on the GAFB study area were as prescribed by the Environmental Protection Agency (EPA) (1973, 1974), American Public Health Association (APHA) (1971), or Parsons and Strickland (1969).

1. Water Chemistry

a) Field Collections and Analyses

Surface dissolved oxygen concentrations and water temperatures were determined in the field, using a Yellow Springs Instruments (YSI) Model 54 D.O. meter which was calibrated daily, using the atmospheric method of calibration described in the YSI manual. Water samples from each site were collected just below the water surface while wearing rubber gloves, and were collected in either a nonmetallic Van Dorn bottle or a hand-held polyethylene bottle. Sufficient water was collected at each site for the following:

- One liter unfiltered, unpreserved sample for pH alkalinity, B , F^-, CL^-, total hardness, turbidity, and specific conductance.
- One liter filtered (using a field filtration apparatus and Gelman GF/A, or equivalent, glass fiber filters), unpreserved sample for determination of NO_3^-, NH_3, PO_4^{2-}, SO_4^{2-}, Si, and cations (Na^+, Ca^{2+}, Mg^{2+}, K^+).
- One liter unfiltered, preserved with 5mls concentrated reagent grade HNO_3, for determination of heavy metals.
- A measured volume was filtered through numbered, preweighed, preashed, glass-fiber filters which were stored in numbered glass vials, for determination of nonfilterable solids and ash-free dry weight.

Water samples were kept in prewashed one-liter polyethylene bottles and stored on ice in a portable cooler for transport to a temporary laboratory in Glasgow. Alkalinity and pH were determined immediately upon return to the laboratory, using an Orion

407A specific ion meter and standard glass pH electrodes. Electrodes were calibrated daily, using standardized pH buffers of 4.0 and 7.0. Sample temperatures were determined, using a standard mercury-glass thermometer. The pH values are expressed at the temperature of determination. Alkalinity was determined by titration with 0.05N or 0.10N standard acid to an end-point of pH 4.5 (APHA 1971). Filtered samples and filters were deep-frozen immediately upon return to the field laboratory, for the preservation of N and P forms (Parsons and Strickland 1969). All samples were transported on ice to the ECON laboratory in Helena for further analysis.

b) Laboratory Analyses

Analyses were begun immediately upon return to the main laboratory in Helena. Components most likely to deteriorate were analyzed first, using the following methods.

• Dissolved $(NO_3^- + NO_2^-)$-N ...	Cd reduction column, sulfanilamide finish (EPA 1974, Parsons and Strickland 1969). Sample concentrations were calculated from standards, using the equations of Parsons and Strickland (1969).
• Dissolved NH_3-N	Manual phenol-hypochlorite method (EPA 1974).
• Dissolved O-PO_4-P	Ascorbic acid single reagent (EPA 1974).
• SO_4^{2-}	$BaCL_2$ turbidimetric method (APHA 1971).
• F^-	Specific ion electrode (EPA 1974).
• CL^-	Diphenylcarbazone (APHA 1971), using HACH reagents.
• Hardness, total	Titrimetric, (APHA 1971), using HACH reagents.
• Ca^{2+}, Mg^{2+}	Atomic absorption (EPA 1974).
• Na^+, k^+	Flame emission (EPA 1974).
• Si	Silico-molybdate method (APHA 1971).
• B	Carmine method (APHA 1971).

Spectrophotometry was done on a B&L Spec 20. Metals analyses (Al, Cr, Cd, Fe, Mn, Pb, Zn, Se) were done by atomic absorption spectrophotometry after extraction in hot HCl + HNO_3 (EPA 1974). All concentrations were determined graphically from standard curves with the exception of (NO_3^- + NO_2^-)-N, as referenced above. The HCO_3^- and CO_3^{2-} concentrations were calculated from pH and alkalinity, using equations from Parsons and Strickland (1969). Results are expressed as $mg \cdot L^{-1}$. Total alkalinity is expressed as $mg \cdot L^{-1} CaCO_3$ (APHA 1971). Turbidity was determined, using an HF Instruments Model DRT-100 turbidimeter, with results expressed as Nephelometric Turbidity Units (NTUs). Specific conductance was determined, using a YSI Model 31 conductivity bridge at 25°C.

B. Results

Water chemistry and/or biological samples were collected from a total of nine sites, six of which were sampled on a regular schedule over a 13-month period. The schedule of sampling at the respective stations is shown in Table E-5.3.1.1.

1. Water Chemistry

Results of chemical analyses of waters are presented in Tables E-5.3.1.2 through E-5.3.1.7. Most waters sampled were similar in composition, reflecting the sedimentary nature of the area's lithology. Dominant cations were Na^+, Ca^{2+}, and Mg^{2+}. Dominant anions were HCO_3^- and SO_4^{2-}. The waters of the study area in general were highly saline, with specific conductances exceeding 1,000 micro-siemens. Aquatic chemistry of each site will be discussed in order. Ion composition is expressed in mili-equivalents per liter, uncorrected for activity.

Concentrations of heavy metals were low in all samples analyzed, as would be expected from highly alkaline waters in the observed pH range draining an area of sedimentary lithology.

a) Site 1

The average composition of the major ions in the nine water samples from this site (Figure E-5.3.1.1) was $Na^+=5.67$, $Mg^{2+}=2.44$, $Ca^{2+}=1.92$, $HCO_3^-+CO_3^{2-}=5.66$, $SO_4^{2-}=3.10$. Values for all major components were lowest in spring samples when snowmelt diluted the

Table E-5.3.1.1

SCHEDULE OF SAMPLE COLLECTIONS FROM AQUATIC SAMPLING STATIONS
MAY 12, 1977 - JUNE 8, 1978

Station	May 12	June 8	July 29	Sept. 4	Oct. 16	Dec. 11	Mar. 8	Apr. 16	June 8
1	X	X	X	X	X	X	X	X	X
2			X	X	X	X	X	X	X
3	X	X	X	X	X	X	X	X	X
4	X	X	X	X	X	X	X	X	X
5	X	X	X	X	X	X	X	X	X
6				X	X	X	X	X	X
1A	X	X							
1B	X								
3A	X								

Table E-5.3.1.2

FIELD CHEMICAL AND PHYSICAL ANALYSES AT GAFB AQUATIC SAMPLING STATIONS MAY 1977 - JUNE 1978

Station	Date	Temperature °C.	D.O. $mg \cdot L^{-1}$	pH	Total Alkalinity $mg \cdot L^{-1}$ $CaCO_3$	Alkalinity $mg \cdot L^{-1}$ $CaCO_3$		
						CO_3^{2-}	HCO_3^-	Non-CO_3^{2-}
1	5/12/77	21	9.9	6.8	298	0	298	0
	6/08/77	22	9.1	8.9	293	26	266	0
	7/28/77	22	8.5	9.4	267	42	225	0
	9/04/77	18	12.4	9.5	264	85	179	0
	10/15/77	8	7.9	8.2	274	3	271	0
	12/11/77	1	7.4	8.3	325	4	321	0
	3/08/78	1	6.8	7.9	398	1	397	0
	4/18/78	4	11.2	7.9	201	1	200	0
	6/07/78	19	8.2	8.4	230	4	226	0
2	5/12/77	--	--	--	--	--	--	--
	6/08/77	--	--	--	--	--	--	--
	7/28/77	22	5.3	9.3	209	27	182	0
	9/04/77	15	9.4	9.8	258	58	200	0
	10/15/77	9	11.6	9.8	178	49	129	0
	12/11/77	1	8.4	9.8	221	51	170	0
	3/08/78	1	0.2	7.7	625	1	624	0
	4/18/78	6	11.8	7.8	60	0	60	0
	6/07/78	18	7.8	7.6	120	0	120	0
3	5/12/77	21	8.4	7.4	315	0	315	0
	6/08/77	20	7.3	8.4	330	10	320	0
	7/28/77	22	10.7	8.4	330	10	275	0
	9/04/77	21	15.8	8.5	310	6	304	0
	10/15/77	12	13.8	8.2	341	4	337	0
	12/11/77	2	5.4	7.8	345	0	345	0
	3/08/78	1	2.7	7.5	346	1	345	0
	4/18/78	7	9.9	8.2	222	3	219	0
	6/07/78	20	8.3	8.2	423	5	418	0

(Continued)

(Table E-5.3.1.2 continued)

Station	Date	Temperature °C.	D.O. mg·L^{-1}	pH	Total Alkalinity mg·L^{-1} $CaCO_3$	Alkalinity mg·L^{-1} $CaCO_3$		
						CO_3^{2-}	HCO_3^-	Non-CO_3^{2-}
4	5/12/77	25	10.1	7.1	295	0	295	0
	6/08/77	5	9.7	8.8	253	16	236	0
	7/28/77	25	8.9	8.1	353	0	353	0
	9/04/77	16	8.2	8.0	349	0	349	0
	10/15/77	9	11.6	8.2	349	3	346	0
	12/11/77	2	0.7	7.7	369	0	369	0
	3/08/78	1	0.2	7.3	425	0	425	0
	4/18/78	10	9.8	8.0	164	1	163	0
	6/07/78	22	6.7	8.2	313	3	310	0
5	5/12/77	25	7.2	7.3	382	0	382	0
	6/08/77	22	9.8	8.5	294	10	284	0
	7/28/77	23	9.1	8.3	355	0	355	0
	9/04/77	19	8.7	8.2	290	0	290	0
	10/15/77	10	9.3	8.1	315	3	312	0
	12/11/77	2	9.4	8.2	400	4	396	0
	3/08/78	1	10.3	7.8	396	1	395	0
	4/18/78	7	9.8	7.8	114	0	114	0
	6/07/78	18	8.3	8.1	202	1	201	0
6	5/12/77	--	--	--	--	--	--	--
	6/08/77	--	--	--	--	--	--	--
	7/28/77	--	--	--	--	--	--	--
	9/04/77	20	10.4	8.6	326	10	316	0
	10/15/77	11	9.2	8.4	338	6	332	0
	12/11/77	2	8.4	8.2	414	5	409	0
	3/08/78	1	7.4	7.7	388	1	387	0
	4/18/78	7	9.8	7.7	100	0	100	0
	6/07/78	19	8.6	8.2	184	2	182	0

Table E-5.3.1.3

LABORATORY CHEMICAL ANALYSES OF WATER SAMPLES FROM GAFB AQUATIC SAMPLING STATIONS MAY 1977 - JUNE 1978

Station	Date	$mg \cdot L^{-1}$				
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Hardness as $CaCO_3$
1	5/12/77	42	30	--	--	230
	6/08/77	60	35	--	5.0	209
	7/28/77	29	30	148	5.0	170
	9/04/77	24	28	162	5.0	174
	10/15/77	29	20	97	3.8	154
	12/11/77	40	38	150	8.0	257
	3/08/78	61	40	172	14.9	235
	4/17/78	34	20	98	6.4	167
	6/08/78	27	26	78	5.2	174
2	5/12/77	--	--	--	--	--
	6/08/77	--	--	--	--	--
	7/28/77	85	86	250	16.0	594
	9/04/77	76	114	265	17.5	660
	10/15/77	61	100	248	18.4	564
	12/11/77	107	130	338	21.6	803
	3/08/78	228	189	800	25.6	962
	4/17/78	50	18	104	6.8	199
	6/08/78	48	38	55	9.2	276
3	5/12/77	51	28	--	--	241
	6/08/77	45	26	165	5.0	232
	7/28/77	56	31	162	5.0	236
	9/04/77	50	30	168	5.0	246
	10/15/77	37	26	117	6.2	199
	12/11/77	57	26	141	7.1	251
	3/08/78	82	36	149	14.4	280
	4/17/78	39	20	47	6.2	178
	6/08/78	27	35	135	7.2	212

(Continued)

(Table E-5.3.1.3 continued)

Station	Date	mg·L^{-1}				
		Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Hardness as $CaCO_3$
4	5/12/77	49	44	--	--	277
	6/08/77	72	28	605	21.6	258
	7/28/77	85	34	236	5.8	294
	9/04/77	69	40	316	7.5	335
	10/15/77	62	23	167	6.2	247
	12/11/77	63	26	236	7.1	264
	3/08/78	94	34	367	14.4	306
	4/17/78	44	16	104	6.4	178
	6/08/78	37	30	135	8.2	215
5	5/12/77	103	54	--	--	446
	6/08/77	80	40	230	9.6	342
	7/28/77	80	46	263	9.6	382
	9/04/77	80	41	220	9.0	369
	10/15/77	86	41	294	10.0	384
	12/11/77	104	58	321	10.0	498
	3/08/78	111	58	312	15.1	398
	4/17/78	41	13	84	7.5	156
	6/08/78	54	37	114	10.0	285
6	5/12/77	--	--	--	--	--
	6/08/77	--	--	--	--	--
	7/28/77	--	--	--	--	--
	9/04/77	87	52	275	11.0	432
	10/15/77	79	41	231	10.0	384
	12/11/77	99	58	340	10.0	498
	3/08/78	104	58	312	15.1	398
	4/17/78	41	9	51	6.2	138
	6/08/78	54	34	114	10.0	273

Table E-5.3.1.4

LABORATORY CHEMICAL ANALYSES OF WATER SAMPLES FROM GAFB AQUATIC SAMPLING STATIONS MAY 1977 - JUNE 1978

Station	Date	mg·L^{-1}							
		B	Cl-	F-	Dissolved Si as SiO_2	SO_4^{2-}	Dissolved Inorg-P as P	Dissolved Inorg-NH_3 as N	$NO_2^- + NO_3^-$ as N
1	5/12/77	--	14.0	.00	--	148	.020	.380	.050
	6/08/77	--	13.8	.48	--	156	.040	.300	.040
	7/28/77	--	12.0	.36	--	210	.065	--	<.010
	9/04/77	--	10.5	.35	10.60	130	.123	.444	<.010
	10/15/77	.085	17.8	.36	7.90	150	.036	.185	.176
	12/11/77	.238	19.0	.36	6.90	132	.102	.053	<.005
	3/08/78	.248	20.0	.47	13.50	207	.104	.060	.185
	4/17/78	.175	5.5	.38	8.10	36	.016	<.005	<.005
	6/08/78	--	9.5	.30	6.50	160	.010	<.005	<.005
2	5/12/77	--	--	--	--	--	--	--	--
	6/08/77	--	--	--	--	--	--	--	--
	7/28/77	--	18.5	.35	--	890	<.010	--	<.010
	9/04/77	--	19.0	.31	4.05	990	.054	.111	<.010
	10/15/77	.298	28.8	.34	2.93	865	.029	.113	.006
	12/11/77	.818	36.8	.38	4.20	--	.013	.032	<.005
	3/08/78	.950	35.0	.73	31.96	938	.940	1.000	≃.005
	4/17/78	.248	39.6	.46	6.50	850	.065	.010	<.005
	6/08/78	--	5.2	.19	4.90	480	.115	.009	<.005
3	5/12/77	--	11.5	.34	--	204	≃.010	.075	.020
	6/08/77	--	11.5	.66	--	197	.300	.160	.060
	7/28/77	--	10.5	.46	--	270	.025	--	<.010
	9/04/77	--	8.9	.45	3.15	180	.011	.292	<.010
	10/15/77	.265	17.3	.40	5.77	128	.006	.135	<.005
	12/11/77	2.98	13.0	.33	10.60	140	.020	.012	.013
	3/08/78	.270	14.5	.38	11.70	228	.029	.051	≃.005
	4/17/78	.270	3.8	.46	9.80	34	.021	<.005	.075
	6/08/78	--	5.0	.53	12.40	224	.017	<.005	<.005

(Continued)

(Table E-5.3.1.4 continued)

Station	Date	mg.L^{-1}							
		B	Cl-	F-	Dissolved Si as SiO$_2$	SO$_4^{2-}$	Dissolved Inorg-P as P	Dissolved Inorg-NH$_3$ as N	NO$_2^-$ + NO$_3^-$ as N
4	5/12/77	--	13.8	.21	--	358	.080	.080	.040
	6/08/77	--	17.0	.87	--	502	.600	.150	.060
	7/28/77	--	17.5	.59	--	315	.011	--	<.010
	9/04/77	--	18.0	.49	10.20	550	.008	.216	<.010
	10/15/77	.150	15.1	.59	7.10	334	.004	.004	<.005
	12/11/77	.375	16.0	.58	12.10	382	≃.005	.035	.031
	3/08/78	.488	20.1	.63	15.10	626	.228	.378	.049
	4/17/78	.255	4.3	.60	9.80	80	.037	.005	.112
	6/08/78	--	7.0	.56	11.00	236	.025	.009	.010
5	5/12/77	--	20.0	.21	--	--	<.010	.875	.030
	6/08/77	--	34.5	.68	--	514	.300	.390	.040
	7/28/77	--	31.5	.40	--	365	.042	--	<.010
	9/04/77	--	29.0	.38	8.70	374	.008	.151	<.010
	10/15/77	.475	28.7	.43	6.46	566	.003	≃.005	<.005
	12/11/77	.438	47.0	.41	8.30	660	≃.005	.108	.105
	3/08/78	.455	41.3	.49	11.70	525	.010	.068	.148
	4/17/78	.188	3.8	.40	4.90	65	.024	.085	<.620
	6/08/78	--	13.3	.31	7.40	302	.017	.019	<.020
6	5/12/77	--	--	--	--	--	--	--	--
	6/08/77	--	--	--	--	--	--	--	--
	7/28/77	--	--	.40	--	--	--	--	--
	9/04/77	--	43.3	.40	9.65	514	.015	.054	<.010
	10/15/77	.408	39.3	.41	6.60	470	.010	≃.004	<.005
	12/11/77	.475	59.0	.43	9.60	660	.014	.275	.170
	3/08/78	.475	46.1	.43	11.36	588	.054	.150	.193
	4/17/78	.140	3.4	.35	3.80	37	.018	.085	.640
	6/08/78	--	12.3	.31	7.50	302	.023	<.005	<.005

Table E-5.3.1.5

METAL CATIONS[1] PRESENT IN WATER SAMPLES FROM GAFB AQUATIC SAMPLING STATIONS COLLECTED ON SEPTEMBER 4, 1977

	$mg \cdot L^{-1}$								
Station	Al	Cr	Cu	[2]Cd	Fe	Mn	[3]Pb	Zn	Se
1	.10	.30	0.010	BLD	0.225	0.058	BLD	0.010	<0.005
2	.10	.32	0.010	BLD	0.156	0.074	BLD	0.024	<0.005
3	.10	.31	<0.010	BLD	0.142	0.028	BLD	0.220	<0.005
4	.11	.38	0.010	BLD	0.500	0.145	BLD	0.025	<0.005
5	.11	.40	0.028	BLD	1.775	0.300	BLD	0.156	<0.005
6	.13	.40	<0.010	BLD	2.260	0.413	BLD	0.022	<0.005

[1] Extracted in HCL and HNO_3.
[2] Below limit of detection ($\approx 0.100\ mg.L^{-1}$).
[3] Below limit of detection ($\approx 0.010\ mg.L^{-1}$).

Table E-5.3.1.6

SPECIFIC CONDUCTANCE AND TURBIDITY OF WATER SAMPLES FROM GAFB AQUATIC SAMPLING STATIONS MAY 1977 - JUNE 1978

Station	Date	Specific Conductance (micro-siemens · cm^{-2} @ 25° C.)	Turbidity (NTU)
1	5/12/77	840	--
	6/08/77	1002	--
	7/28/77	692	--
	9/04/77	895	6.0
	10/15/77	857	3.0
	12/11/77	--	1.0
	3/08/78	1029	3.8
	4/18/78	531	2.2
	6/08/78	560	1.2
2	5/12/77	--	--
	6/08/77	--	--
	7/28/77	1704	--
	9/04/77	2272	0.8
	10/15/77	2028	3.0
	12/11/77	2601	1.7
	3/08/78	2905	[1]32.0
	4/18/78	417	4.2
	6/08/78	681	0.8
3	5/12/77	--	--
	6/08/77	1008	--
	7/28/77	941	--
	9/04/77	1073	1.1
	10/15/77	1014	1.2
	12/11/77	1094	1.2
	3/08/78	996	2.2
	4/18/78	599	5.5
	6/08/78	1037	1.0
4	5/12/77	1292	--
	6/08/77	1435	--
	7/28/77	1276	--
	9/04/77	1947	3.3
	10/15/77	1359	1.6
	12/11/77	1507	3.2
	3/08/78	1760	[1]24.0
	4/18/78	614	5.8
	6/08/78	1245	1.3

(Continued)

(Table E-5.3.1.6 continued)

Station	Date	Specific Conductance (micro-siemens · cm^{-2} @ 25° C.)	Turbidity (NTU)
5	5/12/77	2092	--
	6/08/77	1583	--
	7/28/77	1590	--
	9/04/77	1555	6.5
	10/15/77	1764	10.0
	12/11/77	2112	4.2
	3/08/78	1726	2.3
	4/18/78	491	580.0
	6/08/78	1245	77.0
6	5/12/77	--	--
	6/08/77	--	--
	7/28/77	--	--
	9/04/77	1869	15.0
	10/15/77	1673	20.0
	12/11/77	2198	4.4
	3/08/78	1743	3.6
	4/18/78	398	380.0
	6/08/78	1038	120.0
1A	5/12/77	164	--
	6/08/77	182	--
	7/28/77	150	--

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[1] Affected by sediments disturbed from substrate by sampling.

Table E-5.3.1.7

NON-FILTRABLE RESIDUE FROM WATER SAMPLES FROM GAFB AQUATIC SAMPLING STATIONS
MAY 1977 - JUNE 1978

Station	Total mg.L^{-1} (105° C.)	Ash-free Dry Weight mg.L^{-1} (500° C.)	Percent Ash-free Dry Weight
MAY 1977			
1	--	--	--
2	--	--	--
3	2.42	--	--
4	2.27	--	--
5	15.66	--	--
6	--	--	--
1A	13.80	--	--
1B	40.40	--	--
JUNE 1977			
1	2.33	--	--
2	--	--	--
3	3.02	--	--
4	2.70	--	--
5	27.71	--	--
6	--	--	--
1A	7.24	--	--
SEPTEMBER 1977			
1	14.80	11.84	80
2	2.90	1.62	56
3	4.00	2.88	72
4	9.70	3.49	36
5	29.80	5.66	19
6	31.10	4.04	13
OCTOBER 1977			
1	2.21	1.67	76
2	10.84	3.37	31
3	1.42	1.28	90
4	3.66	0.77	21
5	31.60	7.32	23
6	40.00	4.09	10

(Continued)

(Table E-5.3.1.7 continued)

Station	Total mg.L^{-1} (105^{o} C.)	Ash-free Dry Weight mg.L^{-1} (500^{o} C.)	Percent Ash-free Dry Weight
DECEMBER 1977			
1	7.50	7.50	100
2	5.10	3.43	67
3	5.80	2.21	38
4	5.20	2.16	41
5	4.96	2.42	49
6	9.44	3.76	39
MARCH 1978			
1	11.76	10.50	89
2	20.04	13.52	67
3	6.09	3.01	49
4	26.24	5.50	21
5	5.07	2.38	47
6	5.80	3.26	56
APRIL 1978			
1	5.44	4.73	87
2	10.00	5.80	58
3	6.70	1.05	15
4	10.42	1.77	17
5	703.00	63.00	9
6	465.00	46.50	10
JUNE 1978			
1	13.21	11.62	88
2	3.81	2.67	70
3	2.40	0.94	41
4	3.56	1.64	46
5	128.90	13.28	10
6	171.60	10.20	6

Figure E-5.3.1.1--Aquatic Sampling Site 1, "Trout Pond" groundwater input, and were greatest under ice cover when respiration increased alkalinity and lowered pH, causing increased solubility of major cations. Dissolved N and P values remained high throughout the year, indicating a naturally eutrophic condition. This also was evidenced by the extensive algal blooms occurring in summer. This pond is apparently spring fed, which accounts for the high dissolved oxygen concentrations present throughout the year. The lowest D. O. measured was 6.8 $mg \cdot L^{-1}$ in March 1978, under approximately 90 cm of ice cover and 10 cm of snow. At this time, a profile of D. O. was taken to a depth of 2.5 meters, the maximum depth at the point of sampling. D. O. values remained roughly constant to within 50 cm of the mud-water interface. These levels of D. O. are adequate for survival of trout (FWPCA 1968).

b) Sites 1A and 1B

Site 1A, the gravel pit on the northwest corner of the GAFB, contained water significantly different from all other water samples. The average alkalinity was less than 210 $meq \cdot L^{-1}$, total hardness about 3 $meq \cdot L^{-1}$, with Ca^{2+} as the dominant cation. This would indicate that surface runoff is the major, and probably only, input. Site 1B, on Cherry Creek, showed results substantially similar to Porcupine Creek from the one set of samples collected at this site.

c) Site 2

The average ion composition of water from this site (seven samples) (Figures E-5.3.1.2 and E-5.3.1.3) was: $Na^{+}=12.90$, $Mg^{2+}=7.93$, $Ca^{2+}=4.67$, $SO_4^{2-}=17.4$, $HCO_3^{-}+CO_3^{2-}=4.74$. This is basically a Na-Mg-SO_4 water, having the highest measured concentrations of Na^{+} and SO_4^{2-} of all the sampling stations. The fact that the pond draws down in the winter is responsible for the extremely high total dissolved solids and specific conductances observed in winter samples. The dilution observed in spring is due to surface runoff. Although values for dissolved ortho-phosphorous and inorganic N are lower than those at Site 1, they are still quite high, indicating a naturally eutrophic condition. Inexplicably, the heavy blooms of algae observed at Site 1 were not

Figure E-5.3.1.2. Aquatic Sampling Site 2.

Figure E-5.3.1.3. Biologist collecting water samples at Site 2.

observed at this site. Possibly the shallower depth prevents recycling of nutrients during the ice-free period, or nutrients may be tied up in the heavy macrophyte growths occurring in much of the pond's basin.

d) Sites 3 and 4

Sites 3 and 4 will be discussed together, since they are located about 2.5 kilometers apart in the same drainage. Chemical composition during periods of surface flow was very similar at both stations. However, minor differences reflect the influence of the East Fork and human activity in the drainage. The average major ion composition at Site 3 (eight samples) was: Na^+=5.89, Ca^{2+}=2.46, Mg^{2+}=2.35, SO_4^{2-}=3.7, HCO_3^-=6.33. The average major ion composition at Site 4 (eight samples) was: Na^+=9.70, Ca^{2+}=2.18, Mg^{2+}=2.51, SO_4^{2-}=7.64, HCO_3^-=6.37. This downstream increase in Na^+, Ca^{2+}, and SO_4^{2-} also was reflected in increased specific conductance at Site 4. Fluctuations in chemical composition during periods of no flow are partially attributed to local physical and biological conditions.

Dissolved oxygen concentrations dropped at both sites during periods of ice cover, but were lower at Site 4 due mainly to the presence of a cattle feeding operation immediately adjacent to the site. The effects of this activity also were reflected in the elevated NH_3-N and O-PO_4 concentrations.

Turbidity and nonfiltrable residue (roughly equivalent to suspended solids) appeared to remain low during spring runoff, although sampling was not done during peak flow conditions. This indicates little surface erosion occurring in the upper Porcupine Creek drainage.

e) Sites 5 and 6

Sites 5 and 6 lie about 18 kilometers apart on the Milk River. Water chemistry at both locations is very similar, with slight differences in ion levels attributable to agricultural runoff, groundwater input, and the influence of Glasgow and Nashua on Site 6. Average major ion composition for Site 5 was: Na^+=9.99, Ca^{2+}=4.10, Mg^{2+}=3.55, SO_4^{2-}=8.77, HCO_3^-+CO_3^{2-}=6.11. Average major ion composition for Site 6 was: Na^+=9.59, Ca^{2+}=3.86, Mg^{2+}=3.45, SO_4^{2-}=8.92, HCO_3^-+CO_3^{2-}=6.83. The major difference between Sites 5 and 6, chemically, was the downstream increase in Cl^-, the average concentration of which, at Site 6, was 0.96 milli-equivalents--up from 0.76 at Site 5. The composition of SO_4^{2-} and HCO_3^- also showed a slight downstream increase. Average specific conductance also increased downstream, due primarily to higher values during warm weather. A downstream decrease in turbidity and nonfiltrable residue during peak spring runoff is indicative that some of the sediment bed load is being deposited in this portion of the river, possibly to be resuspended in small quantities under lower flow conditions.

E-5.3.2 Results of Invertebrate Sampling

The variety of habitats to be sampled for aquatic invertebrates required the use of several sampling devices and methods. Benthos samples could not be collected from most sites from December 1977 through March 1978 due to ice cover, although Site 5 was accessible in December. Site 5 was also inaccessible for invertebrate sampling in March 1978 due to heavy ice cover. Sites 5 and 6 were inaccessible to sampling subsequent to ice breakup in April because of severe flooding.

Benthic organisms were collected at Sites 1 and 2, primarily with a Ponar-type dredge (Wildco Wildlife Supply Company). Sampling was done by wading from shore or from a small boat at depths of 3 to 10 feet. Samples were collected in triplicate, combined, and as much detritus washed off through fine mesh netting as possible. The remaining detritus and organisms were placed in labled, screw-top, wide-mouth polyethylene bottles and preserved in the field with formalin. No particular sampling pattern was employed, although all samples were collected within the same general area and care was taken to avoid areas disturbed by wading. The Ponar dredge does not sample organisms associated with upright aquatic plants effectively. Qualitative samples of this epiphytic fauna were collected with a hand net while wading from shore. These samples cannot be used to calculate density data but do yield valuable additional information about the species composition of the benthic community.

Although Sites 3 and 4 were on Porcupine Creek,the usual method of sampling flowing waters, such as Surber or Waters samplers, could not be used most of the year because of the negligible flow. The Surber sampler was used when flow was present. During no-flow conditions sampling was necessarily restricted to the use of artificial substrates and a hand net. Hester-Dendy plates were placed in position at depths of 30-75 cms, left for colonization about six weeks, then removed, using a net to prevent loss of organisms. Invertebrates were scraped from the plates into wide-mouth polyethylene bottles, preserved in formalin, labeled, and taken to the lab for identification. Hand net samples were collected by pushing the lip of a triangular-shaped fine mesh net across the surface of the substrate then washing organisms into sample bottles for preservation. Surber samples were collected whenever sufficient flow was present from riffle areas at a depth of about 25 cms.

Site 5 yielded a large number of samples, as substrates and habitats present offered the opportunity for collecting Surber, Hester-Dendy, dredge, and hand net samples. Surber and Hester-Dendy samples were collected in a riffle area at the downstream end of the site at a depth of 25-30 cms. Sample collection followed previously described procedures. Ponar samples were collected in a pool area at the upper end of Site 5 by wading from shore at a depth of about 80-100 cms. The substrate in this area was an inorganic, clayey silt.

Site 6 proved to be the most difficult to sample. The steep sides and soft, silty substrate prevented wading, the current was inadequate for Surber samples, and a boat was not available at times when dredge samples could be collected. Therefore, sampling was limited to the use of Hester-Dendy plates which were vandalized on one occasion and lost in ice on another, leaving only one set of samples for analysis. The Hester-Dendy plates were anchored from shore on nylon line in about 150 cms of water, left in place for colonization about six weeks, then removed and scraped for organisms.

Invertebrate samples were sieved in the lab to remove as much debris as possible then placed in a white porcelain tray, and the organisms picked with forceps. A hand lens was used to locate smaller forms. Samples with large amounts of debris were subsampled by weighing out a portion of the debris on a balance, picking the organisms from that subsample, then determining a proportion of weights and multiplying to obtain total numbers of organisms in the sample. Samples handled in this manner were also checked completely for the presence of larger forms which might occur infrequently.

Organisms separated from debris were placed in labeled vials, preserved in 95% alcohol, and retained for analysis. Organisms were identified to the lowest possible taxonomic level with the aid of a binocular dissecting microscope, a compound microscope, and taxonomic references by Edmunds et al (1976), Johannsen (1937), Mason (1973), Hilsenhoff (1975), Edmundson (1959), Wiggins (1977), Pennack (1953), and Roemhild (1975). Numbers of individuals per taxa in Ponar and Surber samples were expressed per m^2. Results from Hester-Dendy samplers, which have a total area of $0.093m^2$, were expressed as individuals per three samplers.

Results of the analyses of invertebrate samples collected at Sites 1 and 2 are presented in Tables E-5.3.2.1 and E-5.3.2.2 respectively. The dominance of the chironomid fauna by Chironomus spp. at Site 1 is typical of eutrophic ponds (Brinkhurst 1976). The differences between chironomid fauna at Sites 1 and 2 are marked and may be due to a number of causes: chemistry, substrate, plant productivity, temperature regime, water level regime, or others. The absence of larger forms of chironomids at Site 2 might indicate the effects of severe winter drawdown. Almost certainly, the general impoverishment of the benthic fauna of Site 2 relative to Site 1 (Chironomidae and Trichoptera, in particular) is related to the relative instability at Site 2. Samples collected with a hand net at both sites, a technique which samples the invertebrate community associated with aquatic vascular plants more effectively than a dredge, indicated that damselflies (Odonata - Zygoptera); water boatmen (Hemiptera - Corixidae); and mayflies (Ephemeroptera) are major components of the invertebrate fauna and more numerous than dredge samples indicate. Phantom midge larvae (Culicidae - Chaoborus spp.) were also frequently collected in plankton samples, especially from Site 2.

The results of invertebrate sampling at Sites 3 and 4 are presented in Tables E-5.3.2.3 through E-5.3.2.6, respectively. The invertebrate fauna collected is typical of slow-flowing, warm water streams. Densities of organisms are low, indicating low primary productivity and lack of stability in the community. A significant feature of the data is the catastrophic decrease in numbers of organisms in spring samples, due to severe scouring by runoff and snow melt. Hand net samples collected in September and October contained large numbers of Callibaetis spp.(Ephemeroptera). Apparently this species develops during midsummer and emerges in the fall and does not colonize artificial substrates in proportion to its abundance. The nymphs could be observed resting on fine silt and sand in water about 20 cm deep. Other taxa collected in abundance by hand net included Leptophlebeia (Ephemeroptera), Hyallela, and Gammarus (Decapoda).

Surber and Hester-Dendy samples were collected at Site 5 in a riffle area about 100 meters downstream from an irrigation intake pipe. This riffle had a rubble substrate (64-256 mm linear dimension) (Hynes 1970), which was heavily silted and was about 20-25 cm deep. The invertebrate fauna was dominated by

Table E-5.3.2.1

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED IN PONAR DREDGE SAMPLES AT STATION 1[1]

Taxa	1977					1978	
	May	June	July	Sept.	Oct.	Apr.	June
DIPTERA							
Chironomidae	172						
Tanypodinae							
Ablabesmyia		100	64				
Procaladius				43	151	43	129
Chironominae							
Chironomus			1681	5014	3879	11292	7844
Cryptochironomus			43	14	151		1034
Dicrotendipes					108		71
Endochironomus		29	22				
Glyptotendipes			927	1121	3901	2111	2571
Cladotanytarsus					86		
Micropsectra				14			
Paratanytarsus		43					
Cricotopus		29					
Psectrocladius		14					
Tanytarsus						1	
Pupae		43		29			
Tabanidae		29					
Chrysops	22						
Tipulidae							
Pilaria	86						
Percent of Total No. of Individuals	51	7	67	87	72	96	95
ODONATA						14	
Enallagma	22	14	45				
Ischnura				43			
Lestes		14					
Percent of Total No. of Individuals	4	1	1	<1	0	<1	0
EPHEMEROPTERA							
Baetis		29					
Caenis		287	172	43			225
Callibaetis		14	29				
Parameletus	22						
Percent of Total No. of Individuals	4	8	4	<1	0	0	2

(Continued)

(Table E-5.3.2.1 continued)

Taxa	1977					1978	
	May	June	July	Sept.	Oct.	Apr.	June
TRICHOPTERA							
Halesochila		29					
Hydropsyche				22			
Mystacides		29					
Oecetis		14					
Phyryganea	22		29	22	57		
Polycentropus				22			
Triaenodes		14					
Pupae				22			
Percent of Total No. of Individuals	4	2	1	1	<1	0	0
COLEOPTERA	22						
Percent of Total No. of Individuals	4	0	0	0	0	0	0
HEMIPTERA							
Corixidae						14	
Percent of Total No. of Individuals	0	0	0	0	0	<1	0
AMPHIPODA							
Hyallela	151	1882	1029	733	3112	546	338
Gammarus		1436	201		57		
Percent of Total No. of Individuals	28	82	27	10	27	4	3
GASTROPODA							
Ancylidae	22					14	
Lymnaeadae[2]	P	P	P	P	P	P	
Planorbidae[2]	P	P	P	P	P	P	
Percent of Total No. of Individuals	4					<1	
HIRUDINEA				45	45		
Percent of Total No. of Individuals	0	0	0	1	<1	0	
TOTAL NO. OF TAXA	[3]--	21	14	16	12	9	7
TOTAL NO. OF INDIVIDUALS	541	4020	4539	7137	11,547	14,010	12,212

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

[2] Remains present in numbers too great to count.

[3] Taxonomy incomplete.

Table E-5.3.2.2

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED IN PONAR DREDGE SAMPLES AT STATION 2[1]

Taxa	1977			1978	
	July	Sept.	Oct.	Apr.	June
DIPTERA					
Chironomidae					
Procladius	78		57		203
Chironomus	158				
Dicrotendipes	699				
Glyptotendipes	158				
Cricotopus	23				90
Psectrocladius					225
Microcricotopus	1308				
Culicidae					
Chaoborus			72		
Ceratopogonidae	81				
Percent of Total No. of Individuals.	23	0	2	0	28
ODONATA					
Enallagma			71		
Ischnura	271	99	101		
Percent of Total No. of Individuals.	2	4	3	0	0
EPHEMEROPTERA					
Baetis (?)			14		
Callibaetis	135		330		
Percent of Total No. of Individuals.	1	0	6	0	0
TRICHOPTERA					
Limnephilus					
Spp. 1	23			90	
Spp. 2				90	
Percent of Total No. of Individuals.	<1	0	0	10	0
AMPHIPODA					
Gammarus		49	101	72	113
Hyallela	7622	2313	4280	1580	902
Percent of Total No. of Individuals.	71	88	82	90	54
HIRUDINEA	172	124	101		262
Percent of Total No. of Individuals.	1	5	2	0	14

(Continued)

(Table E-5.3.2.2 continued)

Taxa	1977 July	1977 Sept.	1977 Oct.	1978 Apr.	1978 June
GASTROPODA[2]					
Lymnaeidae[3]	P	P	P	P	P
Planorbidae[3]	P	P	P	P	P
PELYCEPODA					
Pisidium		49	43		68
Percent of Total No. of Individuals	0	2	1	0	4
TOTAL NO. OF TAXA	14	7	12	6	8
TOTAL NO. OF INDIVIDUALS	10,728	2639	5314	1832	1863

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

[2] Not included in total counts of individuals.

[3] Remains present in numbers too great to count.

Table E-5.3.2.3

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED IN SURBER SAMPLES AT STATION 3[1]

Taxa	1977		1978		
	May	June	Mar.	Apr.	June
DIPTERA					
Chironomidae	170				
Tanypodinae					
Ablabesmyia		7			
Theinemannemyia group		4			
Larsia					4
Diamesinae					
Diamesa			96		
Chironominae					
Dicrotendipes		7			
Endochironomous		4			
Paratendipes		4			
Micropsectra		11	730		
Rheotanytarsus		11			44
Acricotopus		18			
Orthocladius			830	15	
Psectrocladius		30			
Zavrelymia			4	4	
Orthocladiinae					
Orthocladius					15
Pupae	33	7	15		
Tabanidae					
Chrysops	11	4			
Culcidae	12				
Ceratopogonidae	15				
Percent of Total No. of Individuals	87	28	93	76	33
ODONATA					
Enallagma					1
Percent of Total No. of Individuals	0	0	0	0	<1
EPHEMEROPTERA					
Centroptilum		1			26
Caenis	3	36	1	2	2
Heptagenia		10			48
Leptophlebia			1		
Siphlonurus		18	1		
Parameletus	5				
Percent of Total No. of Individuals	4	17	<1	8	40

(Continued)

(Table E-5.3.2.3 continued)

Taxa	1977		1978		
	May	June	Mar.	Apr.	June
TRICHOPTERA					
Cheumatopsyche	2		34		
Polycentropus		1	1		
Pupae		1			
Percent of Total No. of Individuals	<1	<1	2		
AMPHIPODA					
Gammarus		175	28	1	1
Hyallela	19	29	65	3	47
Percent of Total No. of Individuals	7	54	5	17	25
COLEOPTERA					
Dysticidae (Adults)	1				3
Percent of Total No. of Individuals	<1	0	0	0	2
HYDRACARINA	1				
Percent of Total No. of Individuals	<1	0	0	0	0
TOTAL NO. OF TAXA	[2]13	18	11	5	10
TOTAL NO. OF INDIVIDUALS	277	378	1791	25	191

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

[2] Includes all chironomid taxa observed at Station 3 throughout the study period.

Table E-5.3.2.4

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED ON HESTER-DENDY PLATES AT STATION 3[1]

Taxa	1977			1978
	June	Sept.	Oct.	June
DIPTERA				
Chironomidae				
Tanypodinae				
Ablabesmyia	25			
Theinemannemyia group	6			1
Chironominae				
Chironomus	6			
Dicrotendipes	25	1	2	
Micropsectra	13			
Paratanytarsus		5		2
Tanytarsus				1
Percent of Total No. of Individuals	34	6	4	10
ODONATA				
Aeschna		4	6	
Anax		1	2	
Enallagma			3	
Ischnura		2	5	
Percent of Total No. of Individuals	0	7	35	0
EPHEMEROPTERA				
Baetidae			2	
Caenis	10	6		2
Callibaetis	2	32	20	3
Heptagenia	5			12
Leptophlebia		2	6	
Percent of Total No. of Individuals	8	41	61	40
TRICHOPTERA				
Cheumatopsyche		1		
Limnephilus	3			
Percent of Total No. of Individuals	1	<1	0	0
COLEOPTERA				
Laccophilus	9			2
Percent of Total No. of Individuals	4	0	0	5

(Continued)

(Table E-5.3.2.4 continued)

Taxa	1977			1978
	June	Sept.	Oct.	June
AMPHIPODA				
Gammarus........................	69	21		3
Hyallela........................	46	32		16
Percent of Total No. of Individuals	52	50	0	45
HIRUDINEA........................	1			
Percent of Total No. of Individuals	<1	0	0	0
TOTAL NO. OF TAXA..................	13	11	8	9
TOTAL NO. OF INDIVIDUALS...........	220	106	46	42

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

Table E-5.3.2.5

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED IN SURBER SAMPLES AT STATION 4[1]

Taxa	1977		1978	
	May	June	Apr.	June
DIPTERA				
Simuliidae				
Simulium				26
Chironomidae				
Tanypodinae				
Ablabesmyia	4	11		
Theinemannemyia group		4		
Chironominae				
Chironomus	118	33		
Dicrotendipes		11		
Micropsectra	7	59		
Rheotanytarsus				4
Acricotopus	170	214	4	
Orthocladius				52
Pupae				33
Tabanidae	4			
Percent of Total No. of Individuals	78	86	22	50
EPHEMEROPTERA				
Caenis	4			7
Callibaetis	30	4		7
Heptagenia	22			81
Leptophlebia	4			
Siphlonuridae	4			
Percent of Total No. of Individuals	17	<1	0	41
TRICHOPTERA				
Cheumatopsyche			7	
Percent of Total No. of Individuals	0	0	39	0
COLEOPTERA				
Laccophilus				4
Percent of Total No. of Individuals	0	0	0	2
AMPHIPODA				
Hyallela	18	33		4
Gammarus		18		4
Percent of Total No. of Individuals	5	13	0	4

(Continued)

(Table E-5.3.2.5 continued)

Taxa	1977		1978	
	May	June	Apr.	June
HIRUDINEA				
Dina..................................			7	7
Percent of Total No. of Individuals......	0	0	39	3
TOTAL NO. OF TAXA........................	11	9	3	11
TOTAL NO. OF INDIVIDUALS.................	385	387	18	229

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

Table E-5.3.2.6

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED ON HESTER-DENDY SAMPLERS AT STATION 4[1]

Taxa	1977				1978
	June	July	Sept.	Oct.	June
DIPTERA					
Simuliidae					
Simulium					1
Chironomidae					
Tanypodinae					
Ablabesmyia			1		
Chironominae					
Chironomus		1	1		
Dicrotendipes	2	14		2	
Endochironomus			3		
Parachironomus			1		
Micropsectra		2	1	1	
Rheotanytarsus					1
Cricotopus	3				
Orthocladius					2
Psectrocladius	1		1		
Pupae			1		
Tabanidae		1			1
Chrysops			1		
Percent of Total No. of Individuals	100	40	4	11	42
ODONATA					
Aeschna			2	6	
Anax				1	
Enallagma			1		
Ischnura				1	
Libellulidae		1			
Percent of Total No. of Individuals	0	2	1	30	0
EPHEMEROPTERA		1			
Centroptilum					1
Caenis			4	2	2
Callibaetis			90	5	
Heptagenia					1
Leptophlebia			1	2	
Percent of Total No. of Individuals	0	2	34	33	33
TRICHOPTERA					
Polycentropus				6	
Percent of Total No. of Individuals	0	0	0	22	0

(Continued)

(Table E-5.3.2.6 continued)

Taxa	1977 June	1977 July	1977 Sept.	1977 Oct.	1978 June
COLEOPTERA					
Dysticidae					
Laccophilus..................					1
Percent of Total No. of Individuals.	0	0	0	0	9
AMPHIPODA					
Gammarus........................			63		
Hyallela........................		7	108	1	2
Percent of Total No. of Individuals.	0	16	61	4	17
HIRUDINEA					
Dina............................		1			
Percent of Total No. of Individuals.	0	2	0	0	0
MOLLUSCA					
Lymnaea.........................		4			
Planorbidae.....................		2			
Percent of Total No. of Individuals.	0	14	0	0	0
TOTAL NO. OF TAXA.................	3	9	14	10	9
TOTAL NO. OF INDIVIDUALS...........	5	43	279	27	12

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

two taxa not found at other sites: *Simulium* (Diptera) and *Cheumatopsyche* (Trichoptera). Other taxa unique to this collecting site were *Dubiraphia* and *Stenelmis* (Coleoptera) (Table E-5.3.2.7).

Ponar and Hester-Dendy samples collected in September-October 1977 from pool areas of Site 5, which have a clayey, inorganic, silt substrate, were dominated by *Endochironomus* and *Glyptotendipes* (Chironomidae), which composed 92% of the total numbers collected. Other data collected from the pool habitat included *Haliplus*, *Dubiraphia*, *Cheumatopsyche*, *Argia*, *Parachironomus*, *Simulium*, *Procladius*, *Theinnamannemyia*, *Cryptochironomus*, *Dicrotendipes*, and *Caenis*. *Simulium* are the buffalo gnats, or blackflies, which as adults are noxious biting pests of humans and animals.

Data on invertebrates from Site 6 are presented in Table E-5.3.2.8. The absence of *Simulium* from the fauna is significant, indicating the lack of any firm substrate in this reach. The number of species collected at this site is also much reduced relative to Site 5, the fauna being almost toally composed of Chironomidae which are burrowing or tube-building forms. The only other species present were *Polycentropus* and *Argia*, both of which inhabit woody debris and submerged roots which are present along the shores of the channel.

A complete faunal list of invertebrates collected in the study waters is presented in Table E-5.3.2.9.

E-5.3.3 Results of Periphyton Survey

Plant pigment (chlorophyll "a") concentrations in acetone extracts were determined by measurement of absorption at 750, 665, 645, and 630 nanometers on a Beckman DU-2 spectrophotometer, then using the values obtained in the trichromatic equations with phaeophytin correction of Parsons and Strickland (1969), where

$\text{Chla} = 11.6\ (665_A) - 1.31\ (645_A) - 0.14\ (630_A)$

665_A = absorption at 665 nanometers,

645_A = absorption at 645 nanometers,

630 = absorption at 630 nanometers, and

Chla = chlorophyll "a" concentration in extracts.

The concentrations in extracts were converted to concentration per m^3 of pond water for plankton, or concentration per m^2 surface area for periphyton, using suitable equations. Pigment extracts and associated organic material were

Table E-5.3.2.7

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED ON HESTER-DENDY PLATES AT STATION 5[1]

Taxa	July	Sept.	Oct.	Dec.
DIPTERA				
Simuliidae				
Simulium....................	8		3140	1067
Chironomidae				
Tanypodinae				
Ablabesmyia..............		4		
Procladius...............		4		
Theinemannemyia group....			2	
Larsia...................				2
Diamesinae				
Diamesa..................				4
Chironominae				
Chironomus...............	1	5		
Dicrotendipes............		1	2	
Endochironomus...........	16	12		
Glyptotendipes...........	22	41		
Parachironomus...........		1		
Polypedilum..............	3		2	3
Cladotanytarsus..........		1		
Micropsectra.............				1
Cricotopus...............				4
Chaetocladius............				16
Pupae......................	2	2		
Percent of Total No. of Individuals	49	74	93	96
ODONATA				
Argia...........................	30	11		
Dromogomphus....................	4	1		
Percent of Total No. of Individuals	32	12	0	0
EPHEMEROPTERA				
Leptophlebia....................			2	
Percent of Total No. of Individuals	0	0	<1	0
TRICHOPTERA				
Cheumatopsyche..................	8		220	30
Polycentropus...................		2		
Percent of Total No. of Individuals	7	2	7	3

(Continued)

(Table E-5.3.2.7 continued)

Taxa	July	Sept.	Oct.	Dec.
COLEOPTERA				
Dysticidae (Adult)..............	1			
Dubiraphia......................	1	12		
Percent of Total No. of Individuals	2	12	0	0
TOTAL NO. OF TAXA..................	10	12	6	8
TOTAL NO. OF INDIVIDUALS...........	106	97	3378	1137

[1] Numbers are expressed per three samplers. Total number of taxa, total number of individuals and percent total individuals in each order are tabulated for each sampling period.

(Table E-5.3.2.7 continued)

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED IN SURBER SAMPLES AT STATION 5[1]

Taxa	May	June	July	Sept.	Oct.	Dec.
DIPTERA						
Simuliidae						
Simulium.........................		756	1585	850	111	81
Pupae.........................		37				
Chironomidae						
Tanypodinae						
Procladius....................		4				
Theinemannemyia group.........	6	59	54	11		
Larsia........................	16				4	4
Diamesinae						
Diamesa.......................			4			
Chironominae						
Chironomus....................				4	4	7
Dicrotendipes.................			4			
Endochironomus................		7			4	
Glyptotendipes................		4	26	11	4	4
Leptochironomus...............		4				
Parachironomus................			74			
Paracladopelma................			11	11		
Polypedilum...................	33	22	870	330	11	11
Phaenopsecta..................	56					
Cladotanytarsus...............		4				
Micropsectra..................		4	4		4	4
Rheotanytarsus................		7	22			
Acricotopus...................	6			4		
Cricotopus....................		11		4		
Microcotopus..................			11			
Orthocladius..................				44	7	4
Pupae...........................		4	155	33		
Empididae...........................			7			
Percent of Total No. of Individuals.....	40	50	63	57	11	11
ODONATA						
Argia.............................			4			
Percent of Total No. of Individuals.....	0	0	<1	0	0	0
EPHEMEROPTERA						
Baetidae............................		4	4			
Caenis............................	6					
Stenonema.........................	6	4			4	
Percent of Total No. of Individuals.....	4	<1	<1	0	<1	0

(Continued)

(Table E-5.3.2.7 continued)

Taxa	May	June	July	Sept.	Oct.	Dec.
TRICHOPTERA						
Cheumatopsyche	139	888	1413	946	1299	910
Polycentropus		85		4		4
Pupae	6		222	40		
Percent of Total No. of Individuals	50	49	37	43	89	89
COLEOPTERA						
Amphizoa (Adult)			4			
Stenelmis	11		4			
Dubiraphia	6			3	4	4
Percent of Total No. of Individuals	6	0	<1	<1	<1	<1
MOLLUSCA						
Ancylidae		4		3		4
Planorbidae					4	
Percent of Total No. of Individuals	0	<1	0	<1	<1	<1
TOTAL NO. OF TAXA	11	18	17	17	12	11
TOTAL NO. OF INDIVIDUALS	291	1993	4467	2302	1460	1032

[1] Numbers are expressed as individuals per square meter. Total number of taxa, total individuals and percent total individuals per order are tabulated for each sampling period.

Table E-5.3.2.8

NUMBERS BY TAXA OF AQUATIC BENTHIC INVERTEBRATES COLLECTED AT STATION 6 ON HESTER-DENDY SAMPLERS IN PLACE FROM SEPTEMBER 4, 1977 - OCTOBER 17, 1977[1]

Taxa	No. of Individuals	Percent of Total Individuals
DIPTERA		
Chironomidae		
Procladius	16	12
Chironomus	14	11
Endochironomus	9	7
Glyptotendipes	91	69
TRICHOPTERA		
Polycentropus	1	<1
ODONATA		
Argia	1	<1
TOTAL NO. OF TAXA	6	
TOTAL NO. OF INDIVIDUALS	132	

[1] Numbers are expressed as individuals per square meter.

Table E-5.3.2.9

TAXONOMIC LIST OF INVERTEBRATE FAUNA COLLECTED DURING THE GAFB AQUATIC STUDY

- CRUSTACEA
  - AMPHIPODA
    - Talitridae
      - *Hyallela azteca*
    - Gammaridae
      - *Gammarus lacustris*

- ANNELIDA
  - HIRUDINEA
    - *Dina*

- INSECTA
  - COLEOPTERA
    - Dysticidae
      - *Laccophilus*
    - Elmidae
      - *Stenelmis*
      - *Dubiraphia*
    - Haliplidae
      - *Haliplus*
  - DIPTERA
    - Ceratopogonidae
    - Chironomidae
      - Chironominae
        - *Chaetocladius*
        - *Chironomus*
        - *Dicrotendipes*
        - *Endochironomus*
        - *Glyptotendipes*
        - *Leptochironomus*
        - *Parachironomus*
        - *Paracladopelma*
        - *Paratendipes*
        - *Polypedilum*
        - *Phaenopsectra*
        - *Cladotanytarsus*
        - *Micropsectra*
        - *Paratanytarsus*
        - *Rheotanytarsus*
        - *Acricotopus*
        - *Zavrelymia*
        - *Cricotopus*
        - *Microcricotopus*
        - *Orthocladius*
        - *Psectrocladius*
      - Diamesinae
        - *Diamesa*
      - Tanypodinae
        - *Ablabesmyia*
        - *Procladius*
        - *Theinemannemyia* group
        - *Larsia*
    - Culicidae
      - *Chaoborus*
    - Empididae
    - Simuliidae
      - *Simulium*
    - Tabanidae
      - *Chrysops*
      - *Tabanus*
    - Tipulidae
      - *Pilaria*
  - EPHEMEROPTERA
    - Baetidae
      - *Baetis*
      - *Callibaetis*
    - Caenidae
      - *Caenis*
    - Heptageniidae
      - *Heptagenia*
      - *Stenonema*
    - Leptophlebeiidae
      - *Leptophlebia*
    - Siphlonuridae
      - *Siphlonurous*
      - *Parameletus*
  - HEMIPTERA
    - Corixidae
  - ODONATA
    - Anisoptera
      - *Dromogomphus*
      - *Anax*
      - *Aeschna*
    - Zygoptera
      - *Argia*
      - *Enallagma*
      - *Ischnura*
      - *Lestes*
      - Libellulidae

(Table E-5.3.2.9 continued)

TRICHOPTERA
Hydropsychidae
Cheumatopsyche
Hydropsyche
Limnephilidae
Halesochila
Limnephilus
Phryganeidae
Phryganea
Psychomyidae
Polycentropus
Leptoceridae
Mystacides
Triaenodes

MOLLUSCA
GASTROPODA
Ancylidae
Lymnaeidae
Lymnaea
Planorbidae
PELECYPODA
Sphaeriidae
Pisidium
Unionidae

retained, dried at 105°C, weighed, ashed at 500°C, and reweighed to determine ash-free dry weights. This was used to calculate autotrophic indices for periphyton samples, where

$$AI = \frac{\text{Ash-free dry weight (mg.m}^{-2}\text{)}}{\text{Chlorophyll "a" density (mg.m}^{-2}\text{)}} \quad \text{(EPA 1973).}$$

Periphyton biomass accrual rates (as units per day) were calculated by dividing the Chla density and ash-free dry weight by the colonization period in days of the slides.

Light penetration of the water columns was determined, using a 20 cm Secchi disk (Wildco Supply Company). Secchi disk depth has been defined as the depth at which approximately 5% of the incident visible light remains (Hutchinson 1957). Depths and depth profiles were determined by taking soundings with a calibrated line at timed intervals along shore-to-shore transects at deeper sites, or with a meter-stick at shallower sites.

The results of periphyton sampling and analysis (chlorophyll and biomass are presented in Table E-5.3.3.1. Rates of chlorophyll and biomass accrual are low in most cases, in spite of an apparent abundance of nutrients at all sites investigated. Maximum accrual occurred at Site 6 in the September 4-October 16 incubation period. It seems unlikely that growth of periphyton was limited by light at other sites where slide holders were anchored on the substrate. The lack of a well developed aufwuchs community at Sites 3 and 4 was notable, although unattached filamentous algae grew profusely, especially under low or no flow conditions. Values for autotrophic indices are all greater than the index value of 100 which the EPA (1973) uses to indicate organic pollution. However, the utility of this index must be questioned, as values obtained by the USGS (1976) for the north fork of the Flathead River ranged from a low of 10 to a high of 1600, with 70% of the values obtained in the range of 300-1600.

E-5.3.4 Game and Non-Game Species

The Milk River and its larger tributaries support a moderately intensive sport fishery for walleye (Stizostedion vitreum), sauger (Stizostedion canadense), northern pike, and goldeye (Hiodon alosoides) (Needham 1978). Other gamefish occurring in the drainage (Brown 1971) are:

Table E-5.3.3.1

PERIPHYTON BIOMASS-CHLOROPHYLL RELATIONSHIPS

Date	Station	No. of Samples	Average Chla ($mg \cdot m^{-2}$)	Average Chla ($mg \cdot m^{-2}/day$)	Average Ash-free Dry Wt. ($mg \cdot m^{-2}$)	Average Autotrophic Index	Average Chla/Pha[1]
9/04/77 - 10/16/77	3	2	1.800	.0399	1,370	761	.72
	4	2	3.348	.0816	1,918	573	.92
	5	2	4.071	.0925	1,728	424	.75
	6	2	10.198	.2487	3,704	363	1.00
10/16/77 - 12/11/77	[2]3	2	--	--	--	1,443	1.05
	4	2	0.654	.0120	981	1,600	1.62
	[2]5	2	--	--	--	817	1.77
4/20/78 - 6/08/78	3	2	1.580	.0320	994	629	24.00
	4	2	3.363	.0690	1,299	386	7.90

[1] Ratio of chlorophyll "a":phaeophytin.

[2] Artificial substrates lost. Autotrophic index calculated using samples collected from native substrates.

Paddlefish	Polyodon Spathula
Channel catfish	*Ictalurus punctatus*
Stonecat	*Noturus flavus*
Pumpkinseed	*Lepomis gibbosus*
Bluegill	*Lepomis macrochirus*
Largemouth bass	*Micropterus salmoides*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Yellow perch	*Perca flavescens*

Nongamefish known to occur in the Milk River drainage include:

Carp	*Cyprinus carpio*
Pearl dace	*Semotilus margarita*
Northern redbelly dace	*Phoxinus eos*
Finescale dace	*Phoxinus neogaeus*
Flathead chub	*Hybopsis gracilis*
Lake chub	*Couesins plumbeus*
Emerald shiner	*Notropis atherinoides*
Silvery minnow	*Hybognathus nuchalis*
Fathead minnow	*Pimphales promelas*
River carpsucker	*Carpoides carpio*
Blue sucker	*Cycleptus elongatus*
Shorthead redhorse	*Moxostoma macrolepidotum*
Longnose sucker	*Catostomus catostomus*
White sucker	*Catostomus commersoni*
Iowa darter	*Etheostoma exile*
Buffalo	*Ictiobus* spp.
Freshwater drum	*Aplodinotus grunniens*

E-5.4--WILDLIFE

E-5.4.1 Major Wildlife Species and Habitat Analysis

Table E-5.4.1.1 presents the frequency of occurrence and percent of area for each habitat type in the areas of analysis using the random observation methodology, as well as the average indices of diversity calculated for this type of site. Tables E-5.4.1.2 and E-5.4.1.3 show the average indices of diversity for the route and incidental observations of each species, respectively. Frequency of occurrence and percent of each habitat type in the area of analysis are presented for each major wildlife species identified (Tables E-5.4.1.4 through E-5.4.1.25).

E-5.4.2 Other Wildlife Species

The following tables summarize ECON's observations of small mammals (Table E-5.4.2.1), avian species (Table E-5.4.2.2) and waterfowl (Table E-5.4.2.3). Peromyscus maniculatus (western deer mouse) was the most common small mammal species observed (via trapping). A number of avian species were present seasonally, and Anas platyrhynchos (mallard), Anas acuta (pintail), Anas discors (blue-winged teal), and Athya affinis (lesser scaup) were the most common waterfowl species observed.

E-5.4.3 Special Surveys

A. Reproduction Indices

Reproduction indices have been determined for the big game species observed on the study area. The fawn:doe ratio for antelope is best determined from August and September observations, as these are the best months for observing and distinguishing the fawns from does. For the antelope observed on the entire 600-square-mile study area during these two months, the fawn:doe ratio was 88:100 and the buck:doe ratio was 58:100. These ratios are based on 142 antelope observed during the period, and they indicate fairly good reproduction among the antelope in that area.

The fawn:doe ratios for the deer species are best determined during the fall months; however, the ratios determined from the observations made between July and November were used to give a sufficient sample size. For

Table E-5.4.1.1

THE FREQUENCIES AND PERCENTS OF AREA OF EACH HABITAT TYPE AND THE AVERAGE INDICES OF DIVERSITY FOR THE AREAS OF ANALYSIS OF 750 RANDOM POINTS FROM THE GAFB STUDY AREA UTILIZING HABITAT DATA FOR THE PERIOD APRIL 1977 - JUNE 1978

	9 - 313		25 - 220		49 - 217		81 -		TOTAL - 750	
HABITAT TYPE	FREQ	% OF AREA	FREQ	% OF AREA	FREQ	% OF AREA	FREQ	% OF AREA	FREQ	% OF AREA
111	96.81	65.92	98.18	67.99	100.00	66.00			98.13	66.55
212	20.77	2.75	33.18	2.54	41.47	2.36			30.40	2.47
220	16.29	1.58	28.64	2.19	32.72	1.88			24.67	1.93
221	1.92	.10	2.27	.18	3.69	.59			2.53	.40
231	45.69	1.96	61.82	2.31	78.80	1.97			60.00	2.07
353	18.53	5.04	20.45	4.33	29.49	5.31			22.27	4.98
510	6.07	1.16	10.45	.83	14.29	.80			9.73	.87
530	37.70	16.73	43.64	16.13	50.69	14.67			43.20	15.41
536	1.60	.89	1.82	.14	4.61	1.55			2.53	1.04
543	10.22	.10	30.45	.10	48.39	.14			27.20	.12
651	7.67	1.43	13.18	1.30	22.58	2.16			13.60	1.80
652	24.28	2.13	35.00	1.74	45.16	2.31			33.47	2.12
653	7.35	.18	17.27	.20	22.58	.16			14.67	.18
654	.64	.02	1.82	.02	5.53	.09			2.40	.06
AVERAGE INDICES OF DIVERSITY	2.701		6.041		10.102				5.822	

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[1] Number of coordinates in area of analysis - number of random points analyzed. The number of coordinates and corresponding sizes of the areas of analysis are: 9 - 230.4 acres; 25 - 640.0 acres; 49 - 1254.4 acres.

Table E-5.4.1.2

THE AVERAGE INDICES OF DIVERSITY OF THE AREAS OF ANALYSIS FOR ROUTE OBSERVATIONS OF THE MAJOR WILDLIFE SPECIES ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

SPECIES	WINTER	NO.	SPRING	NO.	SUMMER	NO.	FALL	NO.	TOTAL	NO.
Antelope	[1]4.346 + <.01	3,383	5.908 - .76	393	7.167 + .05	115	4.593 + <.01	483	4.588 + <.01	4,374
Mule Deer	8.032 + <.01	615	12.317 + <.01	244	14.204 + <.01	89	8.304 + <.01	209	9.460 + <.01	1,157
White-tailed Deer	5.925 + <.01	152	10.782 + <.01	66	11.663 + <.01	105	7.481 + <.01	45	8.623 + <.01	368
Sharp-tailed Grouse	3.626 + <.01	96	5.213 + .20	8	8.733 + .03	1	5.332 + <.01	106	4.568 + <.01	211
Sage Grouse			.716 - <.01	2	.698 - .30	1	22.818 + <.01	4	13.343 + .20	7
Hungarian Partridge	1.733 - .49	4	3.874 + .55	2	5.154 + .21	2	8.843 + <.01	4	5.030 + .30	12
Pheasant	5.804 + .05	3	12.230 + <.01	1			8.568 + <.01	23	8.397 + <.01	27
Waterfowl			4.525 - .03	35	5.606 - .26	170	3.775 - <.01	32	5.199 - .02	237
Coyote	10.722 + .12	3	12.735 + <.01	5	3.375 - .30	4	9.132 + <.01	15	9.123 + <.01	27
Red Fox	6.561 + .84	4	4.907 - .82	1	1.416 - .20	2			4.855 - .60	7
Raptor	17.303 + <.01	23	9.545 - .62	41	9.957 - .88	60	12.640 + .05	34	11.497 + .18	158

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[1] 4.346 - average index of diversity; 3,383 - number of observations; .01 - P-value based on a two-tailed t-test comparing the average indices of diversity for the actual observations with the appropriate average index of diversity from the random observations. A "+" indicates that the average index of diversity for the actual observations was larger than the corresponding average index of diversity for the random observations. A "-" indicates that the former was smaller than the latter.

Table E-5.4.1.3

THE AVERAGE INDICES OF DIVERSITY OF THE AREAS OF ANALYSIS FOR INCIDENTAL OBSERVATIONS OF THE MAJOR WILDLIFE SPECIES ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

SPECIES	WINTER	NO.	SPRING	NO.	SUMMER	NO.	FALL	NO.	TOTAL	NO.
Antelope	[1]4.071 + <.01	1,339	5.278 - .13	63	7.628 + .50	5	4.698 + <.01	20	4.146 + <.01	1,427
Mule Deer					16.755 + <.01	24	5.304 + <.01	16	12.175 + <.01	40
White-tailed Deer	2.231 - .81	2	5.001 - .72	3	7.265 + .02	16			6.462 + .21	21
Sharp-tailed Grouse	3.352 + .02	60	2.501 - .64	88	3.501 + .10	36	1.554 - <.01	67	2.595 - .60	251
Sage Grouse			6.017 - .98	27	3.698 - <.01	9	7.890 + .34	7	5.837 - .65	43
Hungarian Partridge	5.581 + <.01	95	6.215 + <.01	7			2.832 + .59	16	5.245 + <.01	118
Pheasant			8.025 + <.01	4	3.931 + .53	2	1.285 - .61	1	5.892 + <.01	7
Waterfowl	13.016 + <.01	70	6.075 + .93	525	6.187 + .68	372	3.837 - <.01	30	6.537 + .02	997
Coyote	3.948 - <.01	4	11.545 + .28	1	12.014 + .45	3	2.867 - .38	2	6.911 + .58	10
Red Fox	6.252 + .95	2	11.961 + .05	3					9.677 + .16	5
Raptor	13.877 + .58	1	11.422 + .32	31	11.139 + .22	94	9.838 - .89	13	11.100 + .23	139

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[1] 4.071 - average index of diversity; 1,339 - number of observations; .01 - P-value based on a two-tailed t-test comparing the average indices of diversity for the actual observations with the appropriate average index of diversity from the random observations. A "+" indicates that the average index of diversity for the actual observations was larger than the corresponding average index of diversity for the random observations. A "-" indicates that the former was smaller than the latter.

Table E-5.4.1.4

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE ANTELOPE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

	WINTER - 3383			SPRING - 393			SUMMER - 115			FALL - 483			TOTAL - 4374		
HABITAT TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	99.65	53.85	335.18$	100.00	80.08	7.28	100.00	78.25	2.13	100.00	73.06	15.91$	99.73	62.47	231.84$
212	55.51	7.87	146.30$	31.81	1.86	.33	21.74	2.69	6.78	67.49	9.66	640.79$	53.82	6.49	320.84$
220	57.79	4.14	153.82$	20.36	1.44	13.19&	18.26	1.10	6.06	79.30	9.39	406.09$	55.76	3.88	892.48$
221	1.06	.02	13.15&			9.12&			2.67	6.21	.15	47.23$	1.51	.02	18.49#
231	22.49	.38	101.28#	69.21	2.76	9.09*	85.22	2.60	26.67$	24.84	.36	84.57#	28.60	1.00	173.04#
353	59.39	24.54	20.13$	31.04	5.88	27.10$	16.52	2.66	1.09	19.25	4.44	.16	51.28	17.54	13.38$
510	21.40	3.73	357.72$	9.41	.68	.45	6.09	1.04	2.33	8.49	.10	4.95	18.50	2.61	122.34$
530	14.13	2.99	162.27#	23.66	5.25	63.75#	57.39	10.12	8.84*	13.25	1.03	122.92#	16.03	3.70	50.17#
536	.03		52.99#			7.28			2.13			7.85&	.02		111.49#
543	16.26	.05	134.40$	41.73	.09	23.61$	16.52	.09	10.53&	6.63	.04	6.80	17.49	.06	170.45#
651	6.33	1.89	8.63&	9.16	.87	5.54	11.30	.41	.35	10.56	1.16	5.69	7.18	1.53	153.48#
652	9.93	.41	57.24#	33.59	.97	.34	45.22	1.02	5.27	12.22	.36	38.24#	13.24	.56	31.89#
653	8.19	.13	3.48	4.07	.05	47.91#	5.22	.02	11.69&	2.48	.01	16.79#	7.11	.10	17.05#
654	.12		14.49#	2.80	.07	2.10			2.13	5.80	.24	202.00$	.98	.04	37.48#

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.5

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL ANTELOPE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 1339			SPRING - 63			SUMMER - 5			FALL - 20			TOTAL - 1427		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	47.58	378.16$	100.00	78.10	1.16	100.00	75.95	.09	100.00	63.37	.65	100.00	51.48	187.77$
212	40.10	7.74	304.17$	12.70	.38	11.92&	60.00	4.87	1.62	65.00	12.86	23.77$	39.31	6.95	53.58$
220	79.31	4.56	66.42$	34.92	4.79	1.21	60.00	2.74	2.40	65.00	4.91	34.79$	77.08	4.58	224.14$
231			223.57#	74.60	2.00	4.36	60.00	1.65				16.82#	3.50	.24	145.87#
353	24.35	5.37	30.00$	17.46	3.66	.34	60.00	9.76	4.80	65.00	8.67	28.60$	24.74	5.26	5.01
510	19.42	.65	418.39$	3.17	1.25	3.56			.58			1.29	18.36	.70	121.00$
530	56.01	12.67	191.17$	26.98	6.76	7.10			3.87			12.10&	53.75	11.73	64.71$
536	1.64	.28	.01			1.16			.09			.32	1.54	.24	5.65
543	3.81	.01	59.98#	30.16	.11				2.18			2.27	4.91	.02	4.30
651	59.15	20.27	792.33$			9.56&	40.00	3.73	3.14	65.00	8.02	92.82$	56.55	17.68	451.34$
652	22.18	.71	3.20	42.86	2.94	1.70	60.00	1.30	1.37	35.00	2.18	1.25	23.41	.99	64.91#
653	14.12	.15	89.98$	7.94	.01	3.84			1.04			1.58	13.59	.13	1.31

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.6

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE MULE DEER OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 615			SPRING - 244			SUMMER - 89			FALL - 209			TOTAL - 1157		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	47.39	20.26$	100.00	60.70	4.52	100.00	54.70	1.64	100.00	54.65	6.88	100.00	54.40	365.94$
212	92.52	18.94	935.86$	91.39	12.41	372.95$	86.52	12.09	114.19$	86.12	19.18	542.46$	90.67	15.50	352.07$
220	94.15	9.99	348.96$	87.30	6.37	410.74$	82.02	7.63	124.09$	87.56	8.58	778.50$	90.58	8.10	379.08$
221	3.74	.12	10.81*	17.21	.21	245.59$	6.74	.08	8.02*	7.18	.18	30.67$	7.43	.16	112.78$
231	31.54	.50	49.59#	48.36	.99	18.72#	69.66	1.35	2.31	40.19	.90	2.54	39.59	.85	200.91#
353	61.14	19.20	739.58$	58.20	15.83	213.70$	76.40	20.36	171.28$	69.38	15.21	357.94$	63.18	17.60	120.06$
510	6.34	.57	.07	4.51	.33	9.20&	7.87	.55	.63			13.50#	4.93	.41	30.39#
530	11.38	2.01	181.36#	12.70	1.27	94.93#	20.22	2.05	19.83#	7.66	.09	80.32#	11.67	1.50	116.57#
543	4.39	.01	22.77#	24.18	.04	4.52	15.73	.09	9.10&			23.79#	6.64	.03	201.20#
651	9.43	1.12	2.69	15.57	1.34	1.22	7.87	.57	2.19	21.05	.67	52.85$	12.71	1.07	.78
652	3.25	.11	147.91#	29.10	.51	3.73	19.10	.41	9.88&	21.05	.53	1.18	13.14	.35	214.80#
653	3.25	.05	15.16#	3.28	.01	33.43#	6.74	.07	6.90			16.58#	2.94	.03	127.20#
654			3.96			4.52	2.25	.05	.09			1.34	.17	.01	24.50#

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.7

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL MULE DEER OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER -			SPRING -			SUMMER - 24			FALL - 16			TOTAL - 40		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111							100.00	26.61	.44	100.00	50.31	.52	100.00	31.19	.76
212							91.67	11.71	37.02$	43.75	8.65	5.13	72.50	11.12	33.50$
220							100.00	7.51	59.79$	43.75	3.31	8.84*	77.50	6.70	60.07$
231							70.83	1.08	.82			13.46#	42.50	.87	5.10
353							100.00	48.02	93.35$	100.00	9.08	70.34$	100.00	40.49	139.61$
510							8.33	.69	.11	56.25	20.38	70.66$	27.50	4.50	14.38$
530							8.33	3.11	12.16&			9.68&	5.00	2.51	23.78#
543							8.33	.01	5.54			1.82	5.00	.01	9.95&
651									3.64	43.75	5.40	29.41$	17.50	1.04	.51
652							75.00	1.27	16.87$	56.25	2.88	8.89*	67.50	1.58	20.80$

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.8

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE WHITE-TAILED DEER OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 152			SPRING - 66			SUMMER - 105			FALL - 45			TOTAL - 368		
TYPE	FREQ %	OF AREA	CS	FREQ %	OF AREA	CS	FREQ %	OF AREA	CS	FREQ %	OF AREA	CS	FREQ %	OF AREA	CS
111	72.37	30.45	294.02#	100.00	65.02	1.22	100.00	56.45	1.94	100.00	62.38	1.48	88.59	54.18	182.63#
212	25.00	6.64	1.65	81.82	13.08	70.42$	57.14	6.70	27.19$	48.89	10.60	21.62$	47.28	8.79	49.57$
220	26.32	4.24	11.20*	96.97	11.09	150.77$	92.38	9.13	208.73$	86.67	15.86	163.44$	65.22	9.20	325.56$
221	36.18	13.44	947.63$	22.73	.16	124.50$	10.48	2.48	31.87$	4.44	1.20	1.52	22.55	3.89	598.37$
231	28.29	1.62	18.54#	34.85	.79	20.34#	61.90	1.17		60.00	.72	3.71	42.93	1.12	44.65#
353	7.24	3.12	12.84&	34.85	3.68	8.41*	56.19	11.70	82.44$	8.89	.50	2.77	26.36	6.92	3.55
510	5.92	.35		10.61	1.23		19.05	.82	8.29*	4.44	.31	.20	10.33	.81	.14
530	22.37	13.63	15.21#	21.21	2.39	13.49#	47.62	5.34	.67	11.11	.26	13.54#	27.99	5.78	34.69#
536	35.53	23.73	111.22$			1.22	8.57	4.97	26.78$	4.44	2.67	2.31	17.66	7.10	341.75$
543	2.63	.02	9.53&	16.67	.02	5.92	25.71	.10	1.11	6.67	.03	.61	12.23	.06	41.65#
651	6.58	.79	.25	24.24	2.14	7.05	9.52	.35	1.22	31.11	5.02	34.91$	13.59	1.28	
652	41.45	1.49	24.36$	15.15	.37	11.42&	20.95	.65	9.10&	24.44	.45		28.80	.72	3.59
653	21.71	.47	46.03$	6.06	.03	5.80	22.86	.13	2.29			3.56	16.58	.16	1.06

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.9

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL WHITE-TAILED DEER OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 2			SPRING - 3			SUMMER - 16			FALL -			TOTAL - 21		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	13.89	.06	100.00	61.12	.05	100.00	72.37	.29				100.00	68.40	.40
212			.52	100.00	5.52	6.04	6.25	.42	5.23				19.05	1.20	1.27
220			.38	100.00	33.36	7.47	87.50	12.39	27.12$				80.95	15.21	35.79$
231			1.68			4.85	100.00	3.29	9.88*				76.19	2.65	2.29
353			.45			.77	93.75	9.43	52.84$				71.43	7.60	29.31$
510			.12			.34	18.75	1.61	1.17				14.29	1.30	.49
530	100.00	63.44	3.30			2.32	18.75	.02	4.03				23.81	2.41	3.21
543			.22			1.31	62.50	.08	7.76*				47.62	.06	4.42
651	100.00	21.22	24.07$			.45	6.25	.25	.67				14.29	1.00	
652	100.00	1.44	6.23			1.61	6.25	.14	5.81				14.29	.17	3.47

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.10

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE SHARP-TAILED GROUSE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

	WINTER - 96			SPRING - 8			SUMMER - 1			FALL - 106			TOTAL - 211		
HABITAT TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	56.69	3.16	100.00	56.13	.26	100.00	43.33	.03	100.00	57.39	3.49	100.00	56.96	6.95
212	28.13	3.07	3.15	62.50	8.44	8.46*	100.00	1.33	3.81	51.89	7.46	62.36$	41.71	5.49	56.20$
220	86.46	17.37	346.62$	62.50	18.49	12.52*	100.00	1.56	5.13	93.40	16.99	462.15$	89.10	17.14	820.27$
231	23.96	.63	18.27#	25.00	.28	1.38			.84	18.87	.37	30.73#	21.33	.48	50.47#
353	23.96	16.56	1.87	37.50	14.72	1.90			.22	46.23	10.01	53.86$	35.55	13.09	40.46$
530	15.63	4.86	19.91#			4.84	100.00	47.00	1.65	28.30	6.45	3.98	21.80	5.68	22.70#
543			10.92&			.91			.11	4.72	.16	3.49	2.37	.08	14.17#
651	4.17	.30	1.66			.66			.08			8.80&	1.90	.14	9.93&
652	10.42	.49	10.03&	37.50	1.94	.76	100.00	3.78	3.11	48.11	1.17	32.75$	30.81	.90	4.88
653	3.13	.05	2.51			.63	100.00	3.00	12.60*			8.40&	1.90	.04	9.21&

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.11

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL SHARP-TAILED GROUSE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

	WINTER - 60			SPRING - 88			SUMMER - 36			FALL - 67			TOTAL - 251		
HABITAT TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	81.31	1.97	100.00	89.45	2.89	100.00	67.74	1.18	85.07	71.46	29.87#	96.02	79.59	.51
212	40.00	4.70	13.48$	18.18	2.88	.35	22.22	4.51	.04	32.84	6.38	5.92	27.89	4.48	7.72*
220	68.33	9.51	119.17$	20.45	1.70	1.11	41.67	6.30	17.00$	44.78	4.32	39.86$	41.43	4.93	116.37$
231	73.33	2.77	18.47$	86.36	3.95	58.66$	83.33	3.98	20.55$	37.31	2.35	1.89	69.72	3.25	58.41$
353			13.64#	2.27	.54	15.40#	30.56	10.36	3.44			15.23#	5.18	1.68	29.63#
530			36.30#	3.41	.70	44.05#	19.44	6.18	5.10			40.54#	3.98	1.13	121.48#
543	30.00	.37	25.58$	12.50	.27	.49	13.89	.07	.52			7.62	13.55	.19	3.02
651			4.98	1.14	.08	5.30			2.99			5.56	.40	.03	18.74#
652	15.00	.92	2.81	19.32	.44	1.17	19.44	.85	.45	23.88	15.48		19.52	4.63	3.09
653	15.00	.43	5.15			6.98			2.85			5.31	3.59	.10	5.22

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.12

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE SAGE GROUSE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER -			SPRING - 2			SUMMER - 1			FALL - 4			TOTAL - 7		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111				100.00	97.54	.03	100.00	98.44	.01	100.00	68.08	.07	100.00	80.83	.12
212						.99			.49	100.00	13.32	8.05*	57.14	7.61	1.81
220						.80			.40	100.00	4.48	9.96*	57.14	2.56	2.78
231				100.00	2.46	1.23	100.00	1.56	.61	100.00	.28	2.47	100.00	1.09	4.32
651						.30			.15	100.00	12.20	26.34$	57.14	6.97	11.82*
652						1.07			.53	100.00	1.64	7.42	57.14	.94	1.50

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.13

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL SAGE GROUSE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER -			SPRING - 27			SUMMER - 9			FALL - 7			TOTAL - 43		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111				100.00	71.36	.50	100.00	93.39	.16	100.00	79.92	.12	100.00	77.36	.79
212				62.96	6.46	10.80*	88.89	.71	12.59*	85.71	10.32	8.71*	72.09	5.89	29.36$
220				33.33	.20	.29	88.89	2.03	15.98$	100.00	5.02	17.44$	55.81	1.37	15.53$
231				14.81	.49	25.27#	100.00	1.68	5.55	14.29	.18	6.70	32.56	.69	15.59#
530				62.96	4.97	4.09			6.96			5.42	39.53	3.12	.29
543				66.67	.26	16.72$			3.94	85.71	.03	10.09*	55.81	.17	13.06*
651				62.96	14.40	58.47$			1.36			1.06	39.53	9.04	26.10$
652				48.15	1.86	2.05	11.11	2.20	2.25	85.71	2.91	7.91*	46.51	2.10	2.50
653						5.63			1.87	85.71	1.61	22.95$	13.95	.26	.33

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.14

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE HUNGARIAN PARTRIDGE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

	WINTER - 4			SPRING - 2			SUMMER - 2			FALL - 4			TOTAL - 12		
HABITAT TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	34.78	.13	100.00	4.22	.06	100.00	71.44	.06	100.00	23.00	.13	100.00	31.87	.39
212			1.04			.52			.52	100.00	14.78	15.25$	33.33	4.93	1.15
220			.77			.38			.38	100.00	7.00	20.55$	33.33	2.33	2.55
231			3.36			1.68			1.68	100.00	.44	4.75	33.33	.15	.73
353	100.00	20.00	17.58$			.45			.45	100.00	51.44	17.58$	66.67	23.81	18.41$
530	100.00	45.22	6.60			1.21			1.21			2.42	33.33	15.07	.09
543			.45	100.00	.22	17.56$			.22			.45	16.67	.04	.54
651			.33	100.00	89.67	24.07$	100.00	21.67	24.07$			.33	33.33	18.56	11.16*
652			1.28	100.00	5.89	6.23	100.00	6.00	6.23	100.00	3.33	12.47*	66.67	3.09	11.72*
653			.31			.15	100.00	.89	25.21$			.31	16.67	.15	1.52

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.15

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL HUNGARIAN PARTRIDGE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 95			SPRING - 7			SUMMER -			FALL - 16			TOTAL - 118		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	89.47	32.56	16.55#	100.00	49.70	.23				100.00	73.58	.52	91.53	39.14	10.67&
212	8.42	2.79	8.80&	28.57	2.48	.25						4.19	8.47	2.39	10.84&
220	53.68	3.07	97.41$	14.29	4.25	.02				37.50	.29	5.27	49.15	2.77	93.45$
231	21.05	.44	23.23#	100.00	3.89	8.32*				37.50	1.54	.43	27.97	.79	14.93#
510	55.79	8.29	411.89$	28.57	12.73	6.21						1.03	46.61	7.43	340.14$
530	71.58	21.96	46.42$	57.14	22.19	1.12				62.50	14.58	4.18	69.49	20.98	50.77$
543	18.95	.07	7.88*	28.57	.06	2.56						1.82	16.95	.06	5.82
651	45.26	16.67	189.58$			.58				62.50	6.25	67.92$	44.92	14.26	231.14$
652	68.42	13.73	100.68$	57.14	2.92	4.11				62.50	3.75	12.71*	66.95	11.73	116.85$
653	21.05	.29	26.19$	42.86	.35	12.95*						1.26	19.49	.25	25.54$
654	4.21	.14	19.04$	28.57	1.43	85.87$						.10	5.08	.20	36.65$

THIS TABLE FOR OBSERVATION TYPE 1.

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.16

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE PHEASANT OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 3			SPRING - 1			SUMMER -			FALL - 23			TOTAL - 27		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	17.52	.09	100.00	36.11	.03				100.00	39.99	.75	100.00	37.35	.88
212	100.00	14.89	11.44*			.26				13.04	2.19	.83	22.22	3.52	.03
220	100.00	45.19	15.41$	100.00	21.56	5.13				100.00	31.63	118.19$	100.00	32.76	138.74$
353	100.00	11.00	13.18*			.22						5.23	11.11	1.22	.98
510			.19	100.00	20.56	15.47$				86.96	.58	263.92$	77.78	1.26	243.50$
530	100.00	11.41	4.95	100.00	16.00	1.65				86.96	17.78	23.75$	88.89	17.00	30.12$
651			.24			.08				4.35	1.39	.35	3.70	1.19	.59
652			.96	100.00	5.22	3.11				91.30	3.55	56.19$	81.48	3.22	48.05$
653			.23	100.00	.56	12.60*						1.82	3.70	.02	.52
654			.01							86.96	2.90	694.78$	74.07	2.47	289.64$

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.17

THE FREQUENCY OF OCCURRENCE. PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL PHEASANT OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER -			SPRING - 4			SUMMER - 2			FALL - 1			TOTAL - 7		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111				100.00	58.15	.13	100.00	37.67	.06	100.00	69.11	.03	100.00	53.65	.23
212				25.00	4.30	.04			.52	100.00	3.44	3.81	28.57	2.88	.25
220				75.00	16.97	10.11*	100.00	39.17	10.27*	100.00	27.44	5.13	85.71	25.20	24.74$
231				25.00	2.03	.68	50.00	.56	.01			.84	28.57	1.28	.82
353						.90	50.00	3.28	1.31			.22	14.29	.98	.08
510				25.00	5.61	2.51	100.00	19.33	30.94$			.06	42.86	8.88	16.61$
530				50.00	7.12	.25			1.21			.60	28.57	3.92	.24
651				25.00	1.15	1.69			.16			.08	14.29	.63	.43
652				75.00	3.24	5.59			.64			.32	42.86	1.78	1.31
653				100.00	1.27	50.42$			.15			.07	57.14	.70	25.48$
654				25.00	.15	37.32$							14.29	.08	20.49$

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.18

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS
FOR ROUTE WATERFOWL OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

	WINTER -			SPRING - 35			SUMMER - 170			FALL - 32			TOTAL - 237		
HABITAT TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111				100.00	72.13	.64	100.00	86.94	3.15	100.00	91.38	.59	100.00	85.35	4.39
212				20.00	3.19	2.74	38.24	1.04	1.95			15.88#	30.38	1.22	.83
220						14.04#	8.24	1.32	34.63#	15.63	1.93	2.65	8.02	1.20	49.32#
231						56.67#	91.18	2.37	62.07$	100.00	3.49	19.76$	78.90	2.17	29.30$
353						8.99&	13.53	2.73	5.00	15.63	1.14	.45	11.81	2.11	10.86&
510				2.86	.79	2.15	4.71	1.06	5.99			3.73	3.80	.87	11.20&
530				65.71	8.39	6.93	11.76	2.11	70.22#			24.77#	18.14	2.75	62.64#
543				57.14	.18	11.77*	94.71	.72	331.42$	96.88	1.98	66.66$	89.45	.81	389.57$
651				65.71	13.55	84.41$	6.47	.58	6.68			4.85	14.35	2.42	.28
652				45.71	1.63	1.76	60.00	1.13	46.70$	3.13	.10	14.29#	50.21	1.06	24.10$
653				42.86	.14	16.03$	1.76	.01	28.60#			6.67	7.59	.02	15.52#

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.19

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL WATERFOWL OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 70			SPRING - 525			SUMMER - 372			FALL - 30			TOTAL - 997		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FRFQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	42.08	1.29	83.24	33.65	655.95#	100.00	90.06	6.89	100.00	89.39	.55	91.17	56.97	273.90#
212	100.00	4.08	140.97$	29.33	.62	3.50	1.88	.19	164.36#	20.00	1.15	2.35	23.77	.72	39.80#
220	100.00	.92	174.41$	4.19	.23	153.55$	6.45	1.50	89.61#	23.33	4.55	.41	12.34	.88	129.65#
221			1.62	.19	.03	10.23&			8.64&			.69	.10	.02	21.15#
231			113.34#	17.52	.66	436.44$	88.17	3.76	109.44$	100.00	2.38	18.52$	45.14	1.82	117.58#
353			17.99#	.38	.04	129.98#	2.15	.08	76.57#			7.71&	1.00	.05	231.77#
510			8.16&	35.62	6.71	355.39$	3.76	.20	17.77#	3.33	.10	1.62	20.26	3.61	102.54$
530	100.00	33.48	90.40$	81.14	27.44	300.21$	5.91	2.25	215.26#	3.33	.97	19.81#	52.06	17.67	28.71$
536			1.29	.19	.08	7.80&			6.89			.55	.10	.04	16.50#
543	100.00	.12	159.88$	56.76	.43	171.62$	92.74	.87	681.58$	60.00	1.33	12.36*	73.32	.60	391.59$
651	100.00	17.08	461.10$	35.43	1.44	227.10$			56.47#			4.55	25.68	1.96	136.07$
652	100.00	2.08	130.00$	96.00	28.56	21.43$	91.40	1.09	520.09$	3.33	.12	13.22&	91.78	15.60	89.99$
654	100.00	.16	776.15$	3.43	.10	7.60			6.89			.55	8.83	.06	273.90$

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.20

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE COYOTE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

	WINTER - 3			SPRING - 5			SUMMER - 4			FALL - 15			TOTAL - 27		
HABITAT TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	79.11	.05	100.00	72.72	.09	100.00	96.90	.07	100.00	65.35	.27	100.00	72.92	.50
212	33.33	1.59		60.00	4.58	1.62			1.98	53.33	7.42	2.74	44.44	5.15	1.54
220	66.67	5.47	2.12	60.00	2.92	2.40	50.00	.06	.89	80.00	9.66	19.36$	70.37	6.52	23.00$
221			.06			.11			.09	20.00	.17	21.25$	11.11	.09	9.51*
231	66.67	1.69	.02	100.00	3.23	3.08	75.00	1.77	.29	46.67	8.19	1.45	62.96	5.60	.01
353	33.33	8.65	.30	60.00	10.80	4.80			1.02	26.67	5.26	.35	29.63	5.88	1.39
530	33.33	.48	.12	40.00	4.89	.02			3.09	40.00	3.58	.08	33.33	2.95	1.16
543			1.31	40.00	.13	.21	100.00	.43	9.13*	53.33	.20	3.70	51.85	.20	5.83
651	33.33	2.40	1.06			.75	50.00	.48	4.73			2.27	11.11	.34	.10
652	33.33	.61		60.00	.64	1.37	50.00	.36	.39	20.00	.17	1.48	33.33	.33	.03
654			.05	20.00	.10	9.24*			.07			.27	3.70	.02	.53

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

C

Table E-5.4.1.21

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL COYOTE OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 4			SPRING - 1			SUMMER - 3			FALL - 2			TOTAL - 10		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	93.08	.07	100.00	86.24	.01	100.00	85.53	.05	100.00	53.10	.03	100.00	82.14	.18
212			1.98			.49	33.33	4.68				.99	10.00	1.40	2.42
220	50.00	1.20	.89	100.00	.56	2.49	33.33	1.55	.03			.80	40.00	1.00	.63
231	100.00	4.54	2.47	100.00	1.92	.61	100.00	1.60	1.85	100.00	2.96	1.23	100.00	3.08	6.17
353			1.02	100.00	9.32	3.88			.77			.51	10.00	.93	.67
530	50.00	1.18	.06			.77			2.32	50.00	4.50	.03	30.00	1.37	.75
543			1.75	100.00	.16	2.28	33.33	.08	.01			.87	20.00	.04	.51
651			.60			.15	33.33	4.07	1.06			.30	10.00	1.22	.08
652			2.15	100.00	1.80	1.85	100.00	2.49	5.57	50.00	39.44	.19	50.00	8.82	.98

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.22

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE RED FOX OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 4			SPRING - 1			SUMMER - 2			FALL -			TOTAL - 7		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	59.97	.07	100.00	38.92	.01	100.00	98.08	.03				100.00	68.33	.12
212			1.98	100.00	1.12	2.01			.99				14.29	.17	1.12
221	25.00	3.02	9.31*			.02			.04				14.29	1.65	4.55
231	75.00	1.96	.29	100.00	.68	.61	50.00	.06	.11				71.43	1.19	.27
353	25.00	2.47	.05	100.00	58.60	3.88			.51				28.57	10.22	.28
530	25.00	11.32	.56	100.00	.68	1.29	50.00	1.06	.03				42.86	6.60	
536	25.00	12.58	12.02*			.01			.03				14.29	6.86	6.08
543	25.00	.03	.05			.43	50.00	.10	.36				28.57	.05	.01
651	25.00	6.66	.48			.15			.30				14.29	3.63	
652	50.00	1.83	.39			.53	50.00	.70	.19				42.86	1.21	.18
653	25.00	.17	.16			.20			.41				14.29	.09	.04

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.23

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL RED FOX OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 2			SPRING - 3			SUMMER -			FALL -			TOTAL - 5		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	21.94	.03	100.00	69.28	.05							100.00	50.34	.09
212			.99	100.00	1.00	6.04							60.00	.60	1.62
220	50.00	.38	.44	100.00	3.56	7.47							80.00	2.29	6.45
353			.51	100.00	7.12	11.66*							60.00	4.27	4.80
510	50.00	3.98	3.34	100.00	3.04	25.70$							80.00	3.42	25.84$
530	50.00	34.36	.03	100.00	11.08	3.87							80.00	20.39	2.68
543	50.00	.20	.36			1.31							20.00	.08	.25
651	100.00	37.62	13.17*			.45							40.00	15.05	3.14
652	50.00	1.52	.19	100.00	4.44	5.57							80.00	3.27	4.45
653			.41	100.00	.48	14.37$							60.00	.29	6.38

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.24

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR ROUTE RAPTOR OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 23			SPRING - 41			SUMMER - 60			FALL - 34			TOTAL - 158		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	56.97		100.00	67.76		100.00	76.30		100.00	72.27		100.00	70.52	
212	78.26	6.05	12.82*	53.66	2.93	2.50	38.33	2.49	.24	64.71	6.57	7.56	53.80	3.99	9.89#
220	65.22	5.64	11.03*	46.34	4.21	3.45	41.67	3.42	2.18	82.35	5.93	38.04$	55.06	4.48	35.83$
221	4.35	.02	.02	2.44	.01	.18			2.29	8.82	.05	2.52	3.16	.02	.12
231	60.87	2.83	4.42	68.29	3.04	2.70	81.67	2.28	.29	73.53	1.18	.56	73.42	2.31	2.73
353	39.13	7.05	1.02	21.95	4.19	1.12	30.00	4.42		35.29	6.60	.55	30.38	5.20	.06
510	26.09	2.35	2.61	9.76	1.21	.68	13.33	1.43	.04	5.88	.35	1.96	12.66	1.27	.34
530	52.17	14.95	.02	51.22	12.13		26.67	7.23	13.85#	23.53	6.11	10.03&	36.08	9.33	13.50#
543	56.52	.07	.60	34.15	.09	3.33	50.00	.13	.06	41.18	.05	.70	44.94	.10	.75
651	47.83	3.43	8.38*	29.27	2.92	1.04	16.67	.85	1.20	14.71	.53	1.20	24.05	1.68	.19
652	21.74	.47	5.09	31.71	1.43	2.99	48.33	1.31	.24	17.65	.34	10.39&	33.54	1.01	8.60&
653	26.09	.16	.16	21.95	.08		13.33	.05	2.93	2.94	.02	7.50	15.19	.06	4.93
654			1.34			2.39	3.33	.07	.55			1.99	1.27	.03	5.49

THIS TABLE FOR OBSERVATION TYPE 2

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.1.25

THE FREQUENCY OF OCCURRENCE, PERCENT OF AREA, AND CHI-SQUARE VALUE OF EACH HABITAT TYPE FOR THE AREAS OF ANALYSIS FOR INCIDENTAL RAPTOR OBSERVATIONS ON THE GAFB STUDY AREA FOR THE PERIOD APRIL 1977 - JUNE 1978

HABITAT	WINTER - 1			SPRING - 31			SUMMER - 94			FALL - 13			TOTAL - 139		
TYPE	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS	FREQ	% OF AREA	CS
111	100.00	49.41		100.00	77.41		100.00	73.14		100.00	86.17		100.00	75.16	
212	100.00	.04	1.41	41.94	1.48		35.11	1.49	1.56	23.08	1.35	1.81	35.97	1.46	1.73
220			.48	58.06	5.45	9.04*	56.38	5.14	23.90$	38.46	4.90	.19	54.68	5.15	30.43$
231			3.71	90.32	1.97	2.46	87.23	1.76	4.00	84.62	1.78	.26	87.05	1.79	5.66
353			.41	16.13	3.43	2.66	25.53	3.75	.70			5.43	20.86	3.30	4.97
510			.16	9.68	.50	.53	15.96	.58	.21	23.08	.83	.81	15.11	.58	.07
530	100.00	29.22	.97	25.81	5.62	7.67	36.17	7.01	7.92&	15.38	3.15	6.48	32.37	6.50	18.65#
543	100.00	.04	1.06	41.94	.15	.51	46.81	.19	.09	61.54	.63	.89	47.48	.22	.04
651	100.00	18.55	3.42	25.81	2.07	.18	17.02	2.35	1.66			3.79	17.99	2.18	1.67
652	100.00	2.57	1.21	51.61	1.86	.52	52.13	4.48	1.84	53.85	1.18	.39	52.52	3.56	3.03
653	100.00	.16	3.42	12.90	.06	1.66	11.70	.05	6.36			3.79	11.51	.05	9.74&
654			.05			1.81	4.26	.07	.29			.76	2.88	.05	1.87

THIS TABLE FOR OBSERVATION TYPE 1

$ - ACTUAL > RANDOM (.01)
# - RANDOM > ACTUAL (.01)
* - ACTUAL > RANDOM (.05)
& - RANDOM > ACTUAL (.05)

Table E-5.4.2.1

SMALL MAMMALS CAPTURED ON THE GLASGOW AIR FORCE BASE STUDY AREA
FROM SUMMER 1977 THROUGH SPRING 1978

Site No.	Season	Trap Nights	Species	Sex		Age Class				Habitat Type	Average Catch Per Trap-Night
				M	F	Juv.	Sub-Adult	Adult	Total		
1	Summer	120	[1]*P. m.*	1		1			1	Grassland	.01
2	Summer	180	*P. m.*	2	1			3	3	Silver sagebrush-grassland	.02
3	Summer	180	*P. m.*	6	3	2	1	6	9	Creek bottom	.05
4	Summer	180	*P. m.*	11	7		5	13	18	Coulee bottom	.10
5	Summer	300	*P. m.*	5	3			8	8	Grassland	.03
6	Autumn	90	*P. m.*	1	1			2	2	Silver sagebrush-grassland	.02
7	Autumn	147	*P. m.*	2				2	2	Grassland	.01
8	Autumn	90	*P. m.*	1	1		1	1	2	Creek bottom	.03
9	Winter	120	*P. m.*						0	Silver sagebrush-grassland	.00
10	Winter	120	*P. m.*	3	2			5	5	Creek bottom	.04
11	Winter	90	*P. m.*		1			1	1	Grassland	.01
12	Spring	100	*P. m.*	3	2			5	5	Creek bottom	.05
13	Spring	150	[2]*M. o.*	1	2	1		2	3	Grassland	.02
			[3]*R. m.*	4				4	4	Grassland	.03
14	Spring	120	*P. m.*	3	3			6	6	Silver sagebrush-grassland	.05
15	Spring	120	*P. m.*	1	2			3	3	Coulee bottom	.03
16	Spring	120	*P. m.*	6	3			9	9	Juniper-grassland	.08
			M. o.	2				2	2	Juniper-grassland	.02

[1] *Peromyscus maniculatus.*
[2] *Microtus ochrogaster.*
[3] *Reithrodontomys megalotis.*

Table E-5.4.2.2

AVIAN SPECIES OBSERVED BY ECON PERSONNEL ON THE GLASGOW AIR FORCE BASE STUDY AREA DURING APRIL 1977 - JUNE 1978

	[1]Abundance		Habitat Use					Seasonal Occurrence			
	Common	Uncommon	Grassland	Shrub-grassland	Creek bottom	Pond	Residential	Spring	Summer	Autumn	Winter
Western grebe...........		X				X		X	X	X	
Horned grebe............	X					X		X	X	X	
Eared grebe.............	X					X		X	X	X	
Pied-billed grebe.......	X					X		X	X	X	
Double-crested cormorant		X				X			X		
Canada goose............	X					X		X	X	X	
Mallard.................	X					X		X	X	X	X
Pintail.................	X					X		X	X	X	
Gadwall.................		X				X		X	X	X	
American wigeon.........	X					X		X	X	X	
Shoveler................	X					X		X	X	X	
Blue-winged teal........	X					X		X	X	X	
Green-winged teal.......	X					X		X		X	
Redhead.................		X				X		X		X	
Canvasback..............		X				X		X	X	X	
Ring-necked duck........	X					X		X	X	X	
Lesser scaup............	X					X		X	X	X	
Common goldeneye........		X				X		X		X	
Ruddy duck..............	X					X		X	X	X	
Common merganser........		X				X		X		X	
Red-breasted merganser..		X				X		X		X	
Turkey vulture..........	X		X	X					X	X	
Marsh hawk..............	X		X	X				X	X	X	
Rough-legged hawk.......		X	X					X	X	X	X
Ferruginous hawk........		X	X					X	X	X	
Red-tailed hawk.........	X		X	X				X	X	X	
Swainson's hawk.........	X		X	X				X	X	X	
Golden eagle............	X		X	X	X			X	X	X	X
Gyrfalcon...............		X	X								X
Prairie falcon..........		X	X						X		
Pigeon hawk.............		X	X					X	X		
American kestrel........	X		X	X	X		X	X	X	X	
Sharp-tailed grouse.....	X		X	X	X		X	X	X	X	X
Sage grouse.............	X		X					X	X	X	
Ring-necked pheasant....	X				X			X	X	X	X
Hungarian partridge.....	X		X				X	X	X	X	X
Great blue heron........		X			X	X		X	X	X	
Sora....................		X				X		X	X	X	
American coot...........	X					X		X	X	X	
American avocet.........		X	X			X			X		
Killdeer................	X		X			X	X	X	X	X	

(Continued)

(Table E-5.4.2.2 continued)

	^{1}Abundance		Habitat Use					Seasonal Occurrence			
	Common	Uncommon	Grassland	Shrub-grassland	Creek Bottom	Pond	Residential	Spring	Summer	Autumn	Winter
Long-billed curlew	X		X					X	X	X	
Spotted sandpiper		X				X		X	X	X	
Willet	X		X			X		X	X	X	
Lesser yellowlegs		X				X		X	X	X	
Short-billed dowitcher		X				X		X	X	X	
Semipalmated sandpiper		X				X		X	X	X	
Wilson's phalarope		X				X		X			
Northern phalarope		X				X		X	X		
Common snipe		X	X			X		X	X	X	
Herring gull	X		X			X	X	X	X	X	
Ring-billed gull	X		X			X	X	X	X	X	
Common tern		X				X		X	X	X	
Black tern		X				X		X	X		
Mourning dove	X		X	X	X	X	X	X	X	X	
Great-horned owl	X				X	X		X	X	X	X
Snowy owl		X	X								X
Common nighthawk	X		X	X	X	X	X	X	X	X	
Belted kingfisher	X				X			X	X	X	
Red-shafted flicker	X				X			X	X	X	
Red-headed woodpecker		X	X					X			
Hairy woodpecker		X			X			X	X	X	X
Downy woodpecker		X			X			X	X	X	X
Eastern kingbird	X		X	X	X		X	X	X	X	
Western kingbird	X		X				X	X	X	X	
Say's phoebe	X		X				X	X	X	X	
Least flycatcher		X			X			X	X	X	
Western wood pewee		X			X			X	X	X	
Horned lark	X		X	X			X	X	X	X	X
Barn swallow	X		X	X	X	X	X	X	X	X	
Bank swallow	X				X			X	X	X	
Rough-winged swallow	X					X		X	X	X	
Black-billed magpie	X			X	X			X	X	X	X
Common crow		X	X					X			
Black-capped chickadee	X				X						X
House wren	X			X			X	X	X	X	
Catbird	X				X			X	X	X	
Brown thrasher	X				X			X	X	X	
Robin	X				X		X	X	X	X	X
Mountain bluebird		X			X			X			
Cedar waxwing	X		X		X		X	X	X	X	X
Loggerhead shrike		X	X	X				X	X	X	
Warbling vireo		X			X			X	X	X	
Yellow warbler		X			X			X	X	X	
House sparrow	X						X	X	X	X	X
Western meadowlark	X		X	X			X	X	X	X	

(Continued)

(Table E-5.4.2.2 continued)

	[1]Abundance		Habitat Use					Seasonal Occurrence			
	Common	Uncommon	Grassland	Shrub-grassland	Creek Bottom	Pond	Residential	Spring	Summer	Autumn	Winter
Yellow-headed blackbird....	X					X		X	X	X	
Red-winged blackbird.......	X			X	X			X	X	X	
Brewer's blackbird.........	X			X	X		X	X	X	X	
Common grackle.............		X			X		X	X	X	X	
Brown-headed cowbird.......	X		X					X	X	X	
Bullock's oriole...........		X			X			X	X	X	
Pine grosbeak..............		X			X						X
American goldfinch.........	X				X		X	X	X	X	
Rufous-sided towhee........	X				X			X	X	X	
Savannah sparrow...........	X		X					X	X	X	
Lark bunting...............	X		X					X	X	X	X
Vesper sparrow.............	X		X					X	X	X	
Tree sparrow...............		X			X			X	X	X	
Brewer's sparrow...........		X		X						X	
Song sparrow...............	X				X			X	X	X	
McCown's longspur..........		X	X					X	X	X	X
Chestnut-collared longspur.	X		X					X	X	X	X
Snow bunting...............	X		X								X

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[1] Based on observance on study area.

Table E-5.4.2.3

RESULTS OF WATERFOWL SURVEYS OF FIVE SITES ON THE GLASGOW AIR FORCE BASE STUDY AREA APRIL - JUNE 1978

Species	[1]Sex & Age Class	April					May					June				
		Site No.					Site No.					Site No.				
		[2]1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Canada goose	Adult		[3]2(1)	2(1)					2(2)					3(1)		
Branta canadensis	Y															
Mallard	M	3(2)	2(1.5)	1(1)	6(4.5)	1(.5)	2(1.5)	2(1)		9(4.5)	2(1)	3(1.3)		1(.3)	3(2)	9(3.3)
Anas platyrhynchos	F	2(1)	2(1.5)		1(.5)	1(.5)						3(1.7)		5(1.7)	2(1)	3(1)
	Y													3		
Pintail	M	2(1)	4(3.5)	2(1)	3(1.5)		1(.5)	1(.5)		3(2)	3(1.5)	3(1)		1(.3)	1(.7)	1(.3)
Anas acuta	F	1(.5)	2(1.5)	1(.5)				1(.5)			1(.5)	1(.7)		1(.3)	1(.7)	1(.7)
	Y													6		4
Gadwall	M						1(.5)	1(.5)		1(1)	1(.5)	1(.3)		1(.3)		1(.7)
Anas strepera	F							1(.5)		1(.5)	1(.5)					1(.3)
	Y															
American wigeon	M		2(1)	2(1)			1(1)	5(5)		1(.5)	3(1.5)	2(.7)	4(2.3)	4(2.3)		
Anas americana	F						1(1)	1(.5)				2(.7)	1(.3)	1(.7)		
	Y											6				
Shoveler	M	1(.5)			3(1.5)		3(2)	3(2.5)	1(.5)		6(4)	3(1.7)		2(1.3)		3(1)
Anas clypeata	F						2(1)	1(1.5)			4(2)	2(1.5)		1(.7)		
	Y											8				
Blue-winged teal	M	1(.5)		1(.5)			7(6)	10(8)	1(.5)	2(1)	3(1.5)	7(5)		9(3)	4(1.7)	2(1)
Anas discors	F	1(.5)					3(2.5)	3(3)		1(.5)	2(1)	2(1.7)		2(.7)	1(.7)	1(.7)
	Y															
Green-winged teal	M	1(.5)		3(2.5)							4(2)	2(1.3)				
Anas crecca	F	1(.5)		1(.5)							1(.5)					
	Y															
Redhead	M			1(.5)						2(1)		1(.3)				
Aythya americana	F		1(.5)							2(1)		1(.3)				
	Y															
Canvasback	M			1(.5)			7(4)		8(4)	1(1.5)						
Aythya valisineria	F			1(.5)			1(.5)			1(.5)			1(1)			
	Y												3			

(Continued)

(Table E-5.4.2.3 continued)

Species	Sex & Age Class	April					May					June				
		Site No.					Site No.					Site No.				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Ring-necked duck	M						1(1)				2(1)					
Aythya collaris	F						1(1)				2(1)					
	Y															
Lesser scaup	M	2(1)	4(2)	1(.5)	1(.5)		9(4.5)	3(2)	7(6)	1(.5)	2(1)	9(6)	2(.7)	8(5)	3(1.7)	
Aythya affinis	F	1(.5)	2(1)		1(.5)		2(1)	1(1)	2(1.5)		1(.5)	4(2.3)	3(1)		1(.3)	
	Y											15				
Common goldeneye	M		1(.5)													
Bucephala clangula	F			1(.5)												
	Y															
Ruddy duck	M			1(.5)			4(2)		1(.5)			3(1.3)				
Oxyura jamaicensis	F						3(1.5)					1(.3)				
	Y															
Common merganser	M	1(.5)														
Mergus merganser	F															
	Y															
Red-breasted merganser	M		1(.5)	1(.5)												
Mergus serrator	F															
	Y															

[1] Y = young; M = male; F = female.

[2] Site numbers correspond to the pond locations as depicted in Figure E-5.4.2.3.1

[3] Maximum count per month (average count per month). Each pond site was surveyed twice during April and May and three times during June.

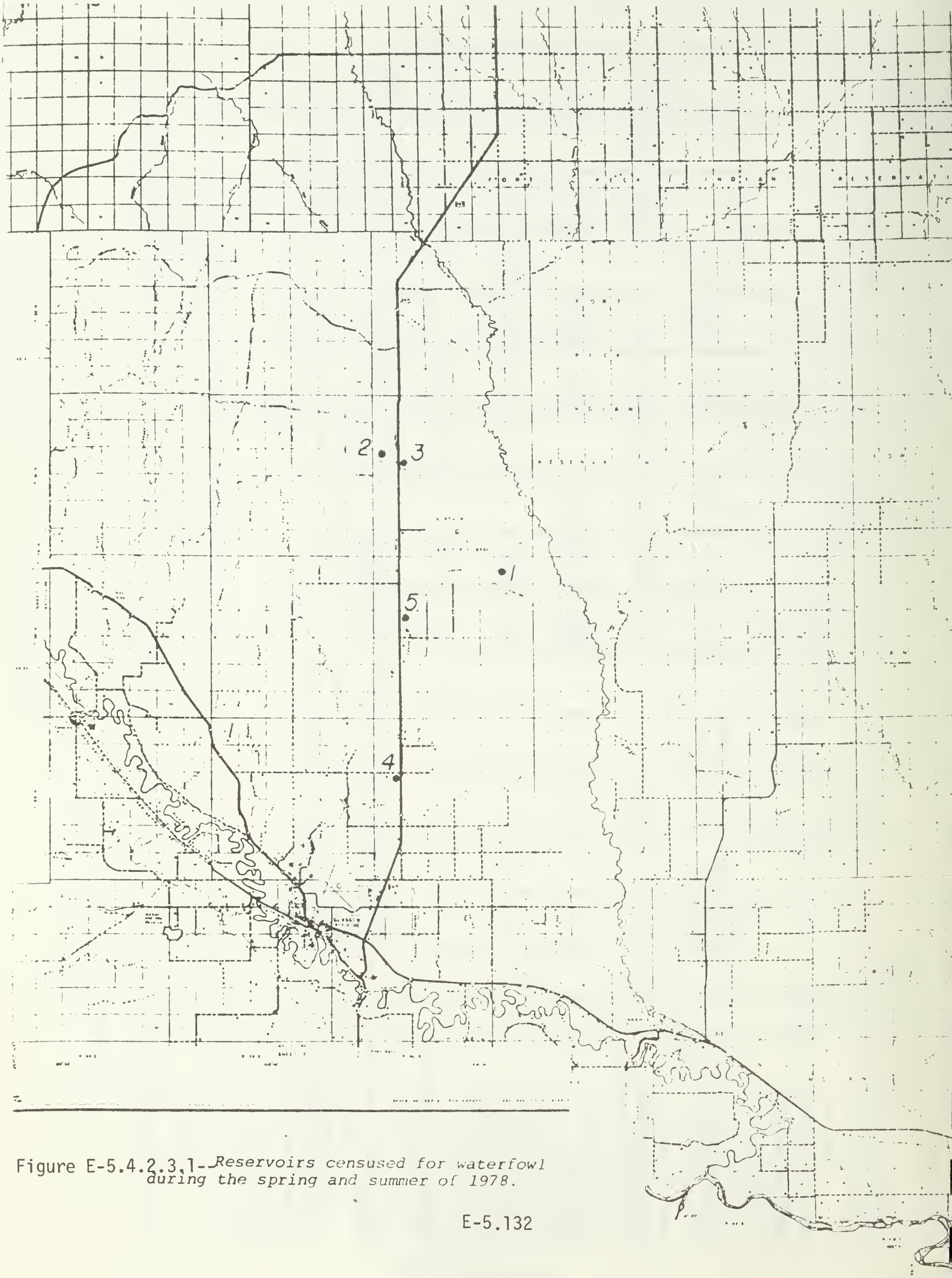

Figure E-5.4.2.3.1--*Reservoirs censused for waterfowl during the spring and summer of 1978.*

the 186 mule deer observed on the study area between July and November, the fawn:doe ratio was 87:100, and for the 217 white-tailed deer observed during the same period, the fawn:doe ratio was 100:100. These ratios indicate good to excellent reproduction among the deer in the study area.

B. Raptor Nest Searches

Raptor nest sites were recorded whenever observed while conducting route or incidental observations. In total, eight raptor nest sites were located (Figure E-5.4.3.1). Two of the sites were harrier (marsh hawk) nests, and one was that of a Swainson's hawk. The remaining five nests had been deserted when located, making positive identification of its prior occupant impossible.

C. Hunting Pressure Surveys

During the immediate post-hunting season period, landowners were contacted to determine hunting pressures on the GAFB study area. All landowners contacted allowed hunting by permission on their holdings, except for a portion of Cherry Creek on which no hunting was allowed.

D. Big Game

The hunting of deer, both white-tailed and mule deer, is restricted to the major drainages and associated breaks. The Milk River and Porcupine Creek are inhabited by white-tailed deer, for the most part, while Cherry Creek and the Lime-Canyon Creek drainages have a higher percentage of mule deer. Porcupine Creek and the Milk River support the greatest hunting pressure, due to accessibility, although it appears that success rates are relatively low. The remaining drainages support less pressure by hunters, yet appear to have higher deer populations.

The resident antelope population during the fall hunting season is relatively low. A majority of the local hunters pursue this species on nearby areas not included in the study area.

Due mainly to readily available and nearby areas with larger big game populations, the study area deer and antelope populations are generally subjected to low hunting pressure.

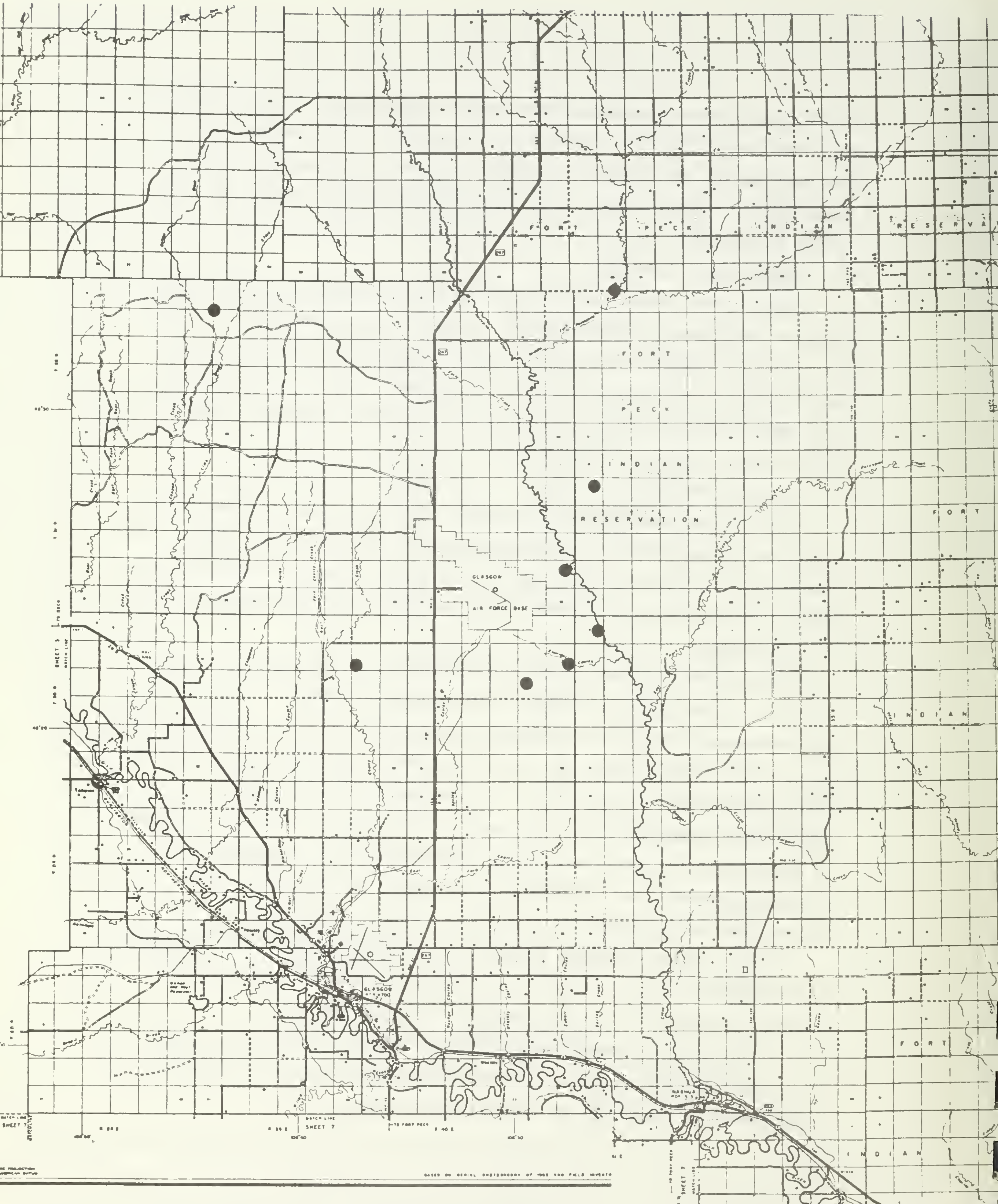
FORT PECK INDIAN RESERVATION
FORT PECK INDIAN RESERVATION
FORT
INDIAN
FORT
INDIAN
GLASGOW AIR FORCE BASE
GLASGOW
NASHUA
247
SHEET 7
SHEET 5
MATCH LINE
TO FORT PECK
BASED ON AERIAL PHOTOGRAPHY OF 1965 AND FIELD REVISION

Figure E-5.4.3.1--Raptor Nest Site Locations

E. Game Birds

The hunting pressure exerted on the gallinaceous game birds, which include sage grouse, sharp-tailed grouse, ring-necked pheasant, and Hungarian partridge, is limited to relatively small portions of the study area due to the restricted distributions of these species. Sage grouse are not common in the area and are taken primarily as a bonus to sharp-tailed grouse hunting.

Sharp-tailed grouse hunting is primarily concentrated in the drainages and larger coulees containing brushy cover. Success has been reported as being good in certain areas including the Cherry Creek and Lime-Canyon Creek drainages.

Pheasant are restricted to the major drainages of the study area and seem to be concentrated near areas where cattle are fed or near grain stubble fields. Hunting pressure is fairly heavy on pheasant along the Milk River, with success reportedly being moderate.

Hungarian partridge populations are relatively low throughout the study area, with most being taken as a bonus while hunting the other game bird species. Pressure on this species as a primary target is negligible.

F. Waterfowl

Waterfowl hunting in the GAFB study area is reportedly very good. The pressure by hunters on waterfowl is restricted to the major drainage systems and their associated grain fields, and to the many reservoirs occuring throughout the area.

G. Furbearers

Coyote, red fox, badger, and raccoon are the major species pursued by fur hunters and trappers in the area. Pressure on coyotes and red fox is very heavy by both hunters and trappers. Trapping during the winter of 1978 was restricted by the heavy snow accumulations, while hunting with aircraft was enhanced by the associated improvement in visibility of these species.

Badgers are common in the study area and are highly sought by trappers (Figure E-5.4.3.2). Early winter conditions again reduced the pressure by trappers, while early trapping was reportedly excellent.

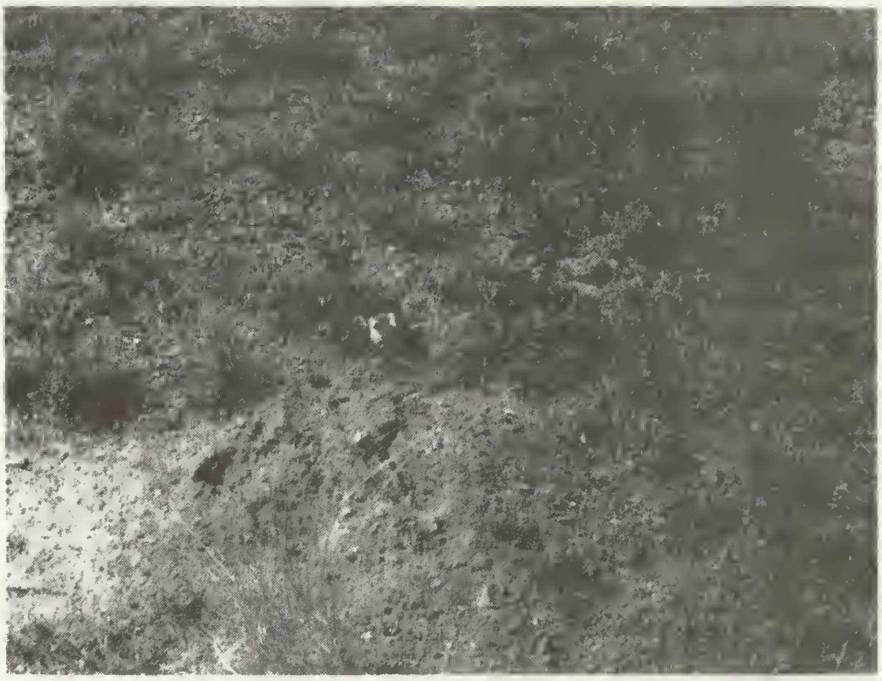

Figure E-5.4.3.2--Badger Emerging from a Burrow on the Study Area

Raccoons are trapped and night-hunted on the Milk River and Porcupine Creek quite heavily. Populations are reportedly increasing, and success was very good during the fall of 1977. The hunting of raccoons with dogs is becoming increasingly popular in the area.

The remaining furbearers, such as mink, muskrat, ermine, and beaver are available but are pursued on a less intensive basis. Beaver are fairly common on Porcupine Creek, but there is no evidence of them being trapped during the winter of 1978. Muskrat and mink are trapped on the major drainages, with success being relatively low.

In conclusion, big game and waterfowl hunting pressure as restricted are relatively low. The pressure on game birds also is restricted but is of a moderate degree. The hunting and trapping pressure on the major furbearers is heavy due to an increased amount of aerial hunting and relatively high fur prices.

E-5.5--VEGETATION

E-5.5.1 Biomass Production, Community Structure, and Site Vegetative Analysis

Figure E-5.5.1.1 depicts the sample site locations selected by ECON, Incorporated as part of MERDI's vegetative baseline studies. Table E-5.5.1.1 indicates biomass (annual aerial) production and percent composition by major plant species at each non-riparian vegetative community sampled. Table E-5.5.1.2 presents the diversity index for each site, together with a site description. At each site, two 100-foot line transects with 2 x 5 decimeter (Daubenmire) frames placed at 10-foot intervals were used to acquire sufficient data for the diversity calculations; the applied formula is shown below:

$$\text{Diversity} = [(\ v_i)/n]*100$$

where v_i = the frequency percent of the i^{th} species

n = the number of species observed in the given transect

The principle is the long-accepted view that as the frequency percent of each species (per transect) increases, while the number of sporadic species decreases, the more stable or mature is that particular plant community.

Through application of SCS Range Site Criteria for glaciated plains areas having 10 to 14 inches annual precipitation, ECON field personnel made the following evaluations: 1) the upland-level grasslands on sandy soil types ranged from fair to good condition, with stocking rates ranging from 4.5 to 5.6 acres/AUM (Animal Unit Month); 2) the upland-hilly grasslands on thin hilly soil types ranged from good to very good condition, with stocking rates ranging from 3.6 to 3.8 acres/AUM; 3) the Carex-Juncus lowlands on seasonally inundated soil types ranged from good to nearly excellent conditions, with stocking rates ranging from 3.2 to 5.0 acres/AUM;and 4) the juniper-grassland site on a thin hilly soil type was in very good condition, having a 316 acre/AUM stocking rate at site number JB-2.

The low-growing woody taxa (i.e., shrubs and semi-shrubs) and deciduous overstory species existing at either the grassland or riparian sites were vegetatively analyzed respectively by 100-foot line intercept transects or point-quarter method; the total seedling count (to measure restocking potential at the riparian sites) utilized the standard 1/100-acre circular

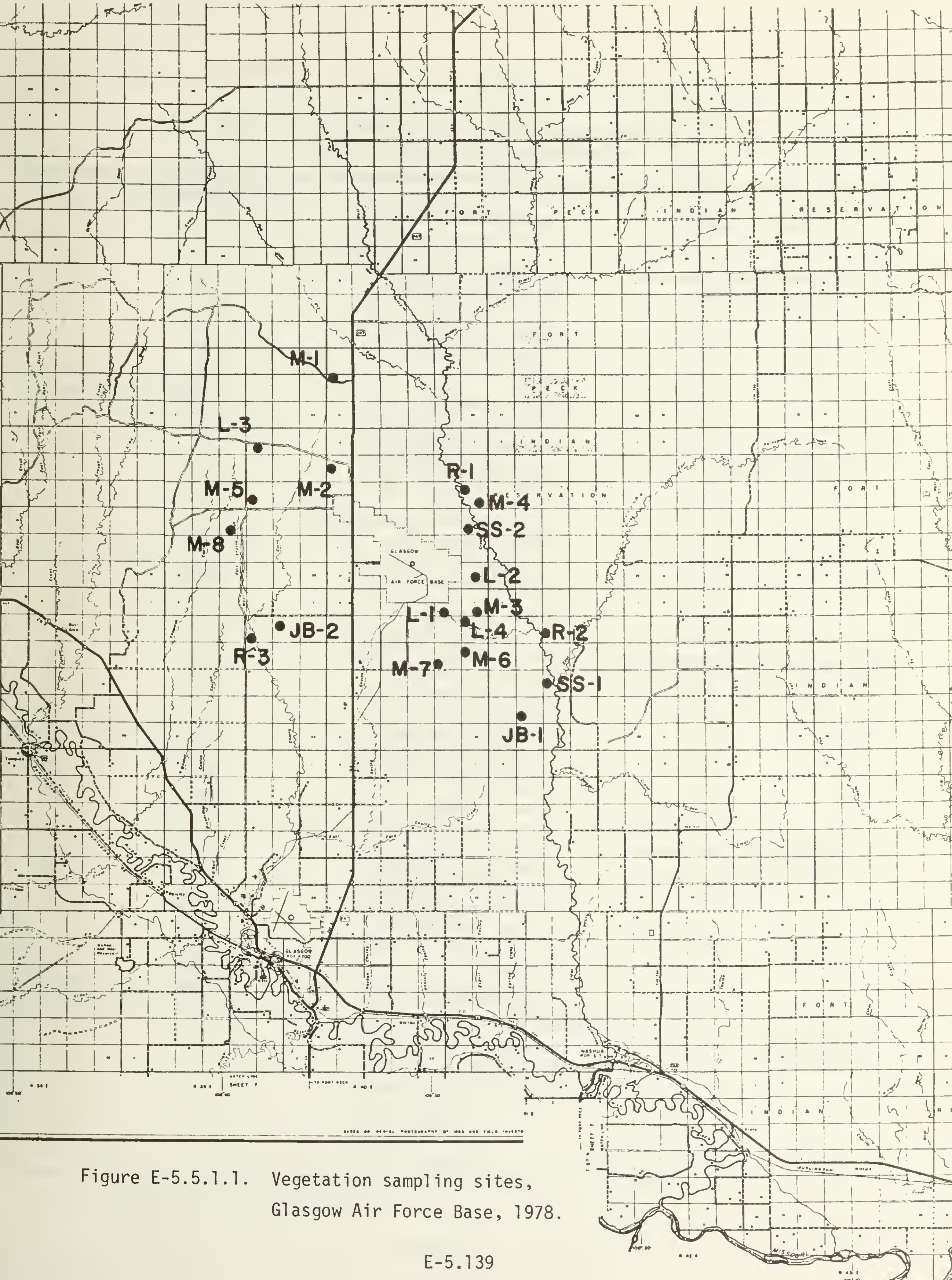

Figure E-5.5.1.1. Vegetation sampling sites, Glasgow Air Force Base, 1978.

Table E-5.5.1.1

PLANT BIOMASS ON NATIVE PLANT COMMUNITY SAMPLE AREAS
GLASGOW AIR FORCE BASE - 1978

Plant Community	Plant Species/Class	1978 Production (lbs/acre - air dry wt.)	% Comp.
(M-1) Upland-level Grassland (AGSM-KOCR-STCO)	*Agropyron smithii*	241	38
	Koeleria cristata	140	22
	Stipa comata	100	15
	Bouteloua gracilis	4	1
	Artemisia frigida	64	10
	Other forbs	90	14
	Total Biomass	639	100
(M-2) Upland-level Grassland (KOCR-AGSM)	*Koeleria cristata*	263	37
	Agropyron smithii	140	20
	Bouteloua gracilis	54	8
	Stipa comata	31	4
	Calamagrostis montanensis	26	4
	Carex stenophylla	21	3
	Artemisia frigida	101	14
	Other forbs	71	10
	Total Biomass	707	100
(M-3) Upland-hilly Grassland (STCO-AGSM-BOGR)	*Stipa comata*	249	31
	Agropyron smithii	159	20
	Bouteloua gracilis	90	11
	Koeleria cristata	75	9
	Carex stenophylla	24	3
	Artemisia frigida	88	11
	Other forbs	114	14
	Total Biomass	799	99
(M-5) Upland-hilly Grassland (STCO-KOCR-BOGR)	*Stipa comata*	177	32
	Koeleria cristata	169	30
	Agropyron smithii	57	10
	Bouteloua gracilis	52	9
	Carex stenophylla	15	3
	Artemisia frigida	44	8
	Other forbs	43	8
	Total Biomass	557	100

(Continued)

(Table E-5.5.1.1 continued)

Plant Community	Plant Species/Class	1978 Production (lbs/acre - air dry wt.)	% Comp.
(M-7) Upland-level Grassland (AGSM-CAMO-KOCR)	*Agropyron smithii*	169	26
	Calamogrostis montanensis	124	19
	Koeleria cristata	121	19
	Bouteloua gracilis	81	12
	Stipa comata	38	6
	Carex stenophylla	30	5
	Artemisia frigida	40	6
	Other forbs	46	7
	Total Biomass	649	100
(L-1) Sedge Meadow (CAREX-JUNCUS)	*Carex* spp.	2200	68
	Juncus spp.	586	18
	Calamagrostis montanensis	123	4
	Sporobolus airoides	6	[1]tr
	Hordeum jubatum	tr	tr
	Other forbs	295	9
	Total Biomass	3210	99
(L-2) Lowland (AGSM-DIST-KOCR)	*Agropyron smithii*	514	46
	Distichlis stricta	259	23
	Poa secunda	144	13
	Poa canbyi	72	7
	Artemisia frigida	50	5
	Other forbs	68	6
	Total Biomass	1107	100
(L-3) Lowland (DIST-AGSM-KOCR)	*Distichlis stricta*	189	21
	Agropyron smithii	185	21
	Koeleria cristata	112	13
	Bouteloua gracilis	60	7
	Poa canbyi	20	2
	Poa secunda	20	2
	Carex spp.	92	10
	Artemisia frigida	tr	tr
	Juncus spp.	tr	tr
	Other forbs	208	24
	Total Biomass	886	100
(JB-2) Juniper-Grassland (ANSC-CALO)	*Andropogon scoparius*	315	27
	Calamovilfa longifolia	368	32
	Calamagrostis montanensis	tr	tr
	Carex pennsylvanica	tr	tr
	Thermopsis rhombifolia	351	30
	Artemisia ludoviciana	63	6
	Other forbs	30	3
	Rosa woodsii	23	2
	Total Biomass	1150	100

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[1] tr = trace, a value less than .5%.

Table E-5.5.1.2

DIVERSITY INDICES FOR FOURTEEN SAMPLING SITES ON THE GLASGOW AIR FORCE BASE 200-SQUARE-MILE STUDY AREA - 1978

Sample Site	Site Description	Diversity Index
M-1 (AGSM-KOCR-STCO)	Upland-level Grassland	46.1
M-2 (KOCR-AGSM)	Upland-level grassland	61.2
M-3 (STCO-AGSM-BOGR)	Upland-hilly Grassland	53.1
M-4 (KOCR-AGSM-STCO)	Upland-level Grassland	50.3
M-5 (STCO-KOCR-BOGR)	Upland-hilly Grassland	60.6
M-6 (STCO-BOGR-KOCR)	Upland-hilly Grassland	57.3
M-7 (AGSM-CAMO-KOCR)	Upland-level Grassland	47.5
M-8 (AGSM-KOCR-BOGR)	Upland-level Grassland	23.6
JB-1 (ANSC-KOCR)	Juniper-Grassland	23.6
JB-2 (ANSC-CALO)	Juniper-Grassland	49.0
L-1 (CAREX-JUNCUS)	Sedge Meadow	54.4
L-2 (AGSM-DIST-POSE)	Coulee Bottom	28.4
L-3 (DIST-AGSM-KOCR)	Coulee Bottom	32.5
SS-1 (ARCA-BOGR)	Silver Sage-Grassland	45.8

plot technique. The results of these studies are summarized in Tables E-5.5.1.3 and E-5.5.1.4 for shrubby and overstory community types, respectively.

Analysis of the shrub data indicates the relative species distribution or "tolerance" within the various observed plant community types or habitats, e.g., silver sage existing on well-drained plains, while Wood's rose exists from mesic coulee bottoms to drier plains conditions. Evaluation of the deciduous tree data indicates that: 1) the high stand density and dominance by peachleaf willow at the northern Porcupine Creek sites implies a less mature community than observed at the other creek bottom habitat types, 2) the high frequency of green ash seedlings at the southern Porcupine Creek site probably implies that the community is in a more advanced seral stage, and 3) the dense stand of green ash, with its dominating canopy coverage, implies it is probably at the most advanced successional stage of the three monitored sites.

Table E-5.5.1.3

CANOPY COVERAGES OF HALF-SHRUB/SHRUB COMMUNITIES ON THE GLASGOW AIR FORCE BASE 200-SQUARE-MILE STUDY AREA - 1978

Sampling Site	Taxa	Frequency	Height Class (inches) 0-6	6-12	12-18	18-24	24-30	Total Percent Canopy
(L-3) Coulee Bottom	*Glycyrrhiza lepidota*	10	--	2	1	--	--	3
	Rosa woodsii	30	--	1	1	--	--	2
	Symphoricarpos albus	10	[1]tr	1	--	--	--	1
								6
(L-4) Coulee bottom	*Artemisia cana*	30	tr	5	--	--	--	5
	Rosa woodsii	50	--	3	2	--	--	5
	Symphoricarpos albus	70	2	7	2	--	--	11
								21
(JB-1) Juniper-Grassland	*Juniperus horizontalis*	100	42	--	--	--	--	42
	Rosa woodsii	10	1	--	--	--	--	1
								43
(JB-2) Juniper-Grassland	*Juniperus horizontalis*	80	34	--	--	--	--	34
								34
(SS-1) Silver Sage-Grassland	*Artemisia cana*	90	1	4	7	10	8	30
								30
(SS-2) Silver Sage-Grassland	*Artemisia cana*	100	1	8	12	--	3	24
								24

[1] tr = trace, a value less than .5%.

Table E-5.5.1.4

PARAMETERS OF THE OVERSTORY VEGETATION ON THREE CREEK BOTTOM SITES AT GLASGOW AIR FORCE BASE - 1978

Sampling Site	Taxa	Relative Density (%)	Relative Dominance (%)	Relative Frequency (%)	Importance Value	Additional Parameters Descriptive of the Sampling Site
(R-1)	*Fraxinus pennsylvanica*	10	8	25	43	Mean distance (feet).......... 22.8
North	*Populus deltoides*	10	26	42	78	Mean area occupied by an
Porcupine	*Prunus virginiana*	8	1	25	34	individual ($feet^2$).......... 519.8
Creek	*Salix amygdaloides*	71	65	92	228	Density (# individuals/acre).. 83.8
						Total basal area ($\frac{inches^2}{acre}$)....43,563
						Average DBH (inches).......... 13.3
(R-2)	*Fraxinus pennsylvanica*	68	22	92	182	Mean distance (feet).......... 29.5
South	*Populus deltoides*	28	70	67	165	Mean area occupied by an
Porcupine	*Salix amygdaloides*	4	7	17	28	individual ($feet^2$).......... 870.3
Creek						Density (# individuals/acre).. 50.1
						Total basal area ($\frac{inches^2}{acre}$)....43,599
						Average DBH (inches).......... 8.6
(R-3)	*Fraxinus pennsylvanica*	89	78	100	267	Mean distance (feet).......... 20.5
Cherry	*Salix amygdaloides*	11	22	25	58	Mean area occupied by an
Creek						individual ($feet^2$).......... 420.5
						Density (# individuals/acre).. 103.7
						Total basal area ($\frac{inches^2}{acre}$)....43,590
						Average DBH (inches).......... 8.2

E-5.6--SOCIOECONOMICS

Agricultural, business volume, and personal income and employment statistics for Valley County were compiled to provide Valley County socioeconomic baseline data.

E-5.6.1 Commerce Statistics

Baseline data on business volume in Valley County was obtained from the U. S. Department of Commerce utilizing the U. S. Corps of Engineers Construction Engineering Research Laboratory (CERL) Economic Information Forecasting System (EIFS) Subprogram (see Table E-5.6.1.1, E-5.6.1.2, E-5.6.1.3)

Table E-5.6.1.1

VALLEY COUNTY BUSINESS (CENSUS STATISTICS)

BUSINESS VOLUME -- 1967	
Manufacturing:	$ 300,000.00
Retail:	$ 21,408,000.00
Service:	$ 1,360,000.00
Wholesale:	$ 22,037,000.00
BUSINESS VOLUME -- 1972	
Manufacturing:	$ 400,000.00
Retail:	$ 23,980,000.00
Service:	$ 5,000,000.00
Wholesale:	$ 39,813,000.00
1972 Total:	$ 69,193,000.00
1967 Total:	$ 45,105,000.00

All dollar amounts are in thousands of dollars. Dollar adjustment based on consumer price index (1967=100).

Table E-5.6.1.2

BUSINESS VOLUME (USING NON-FARM INCOME)

YEAR	NON-FARM INCOME	ADJUSTED INCOME	CHANGE	DEVIATION	%DEVIATION
1965	35,739	37,812			
1966	39,095	40,229	2,417	3,588	9.488%
1967	41,478	41,478	1,249	2,420	6.016%
1968	28,778	27,627	-13,851	-12,680	-30.571%
1969	23,849	21,726	-5,900	-4,730	-17.120%
1970	25,365	21,814	87	1,258	5.791%
1971	28,126	23,176	1,362	2,533	11.610%
1972	31,021	24,786	1,610	2,781	11.998%
1973	33,002	24,818	32	1,202	4.851%
1974	37,590	25,486	669	1,839	7.411%
1975	41,568	26,105	619	1,789	7.021%

Average Yearly Change = -1,171

Maximum Historic Positvie Deviation	3,588
Maximum Historic Negative Deviation	-12,680

*Positive RTV = 9,488
*Negative RTV = -22.929

Source: Construction Engineering Research Laboratory (CERL), Economic Information Forecasting System (EIFS) Subprogram.

*The positive Rational Threshold Value (RTV) equals the largest positive percent deviation in the historical record. The negative RTV is 75 percent of the maximum historic negative deviation.

Table E-5.6.1.3

VALLEY COUNTY CENSUS OF BUSINESS, 1972

Dir. Gen Expend:	4,918,000.00
Educational Expend:	3,232,000.00
Total Assessed Value:	8,382,000.00
Assessed to Sales Price Ratio:	8.80
Property Taxes:	2,957,000.00
Value Added -- MFGR:	0.00
Retail Sales:	23,980,000.00
Service Receipts:	5,000,000.00
Wholesale Sales:	39,813,000.00

Source: Construction Engineering Research Laboratory, Economic Information Forecasting System.

E-5.6.2 Agricultural Statistics

Agricultural data for Valley County was obtained from the 1974 Census of Agriculture, U.S. Department of Commerce, and the Bureau of the Census, May 1977. The following data were evaluated:

- Farms, Land in Farms, and Land Use: 1974 and 1969
- Farm Operators--Tenure and Characteristics: 1974 and 1969
- Market Value of Agricultural Products Sold: 1974 and 1969
- Income From Sources Other Than Sale of Agricultural Products: 1974 and 1969
- Farm Production Expenses: 1974 and 1969
- Machinery and Equipment on Place: 1974 and 1969
- Cattle and Calves--Inventory and Sales: 1974 and 1969
- Hogs, Sheep, Goats, and Horses--Inventory and Sales: 1974 and 1969
- Poultry--Inventory and Sales: 1974 and 1969
- Irrigation and Commercial Fertilizer on Pastureland and Harvested Crops for Farms With Sales of $2,500 and Over: 1974 and 1969
- Agricultural Chemicals Used and Cost of Materials for Farms With Sales of $2,500 and Over: 1974 and 1969
- Irrigation, Artificial Drainage, and Artificial Ponds for Farms With Sales of $2,500 and Over: 1974 and 1969
- Farm Credit for Farms With Sales of $2,500 and Over: 1974

E-5.6.3 Employment (Valley County)(See Tables E-5.6.3.1, E-5.6.3.2, E-5.6.3.3)

Table E-5.6.3.1

YEAR	EMPLOYMENT	CHANGE	DEVIATION	% DEVIATION
1969	5,943			
1970	4,922	-1,021	-963	-16.204 %
1971	4,930	8	66	1.341 %
1972	5,086	156	214	4.341 %
1973	5,446	360	418	8.219 %
1974	5,398	-48	10	0.184 %
1975	5,595	197	255	4.724 %

Average Yearly Change:	-58
Maximum Historic Positive Deviation:	418
Maximum Historic Negative Deviation:	-963
Positive RTV:	8.219
Negative RTV:	-10.857

*The positive Rational Threshold Value (RTV) equals the largest positive percent change in the historical record. The negative RTV is 67 percent of the maximum historic negative deviation.

Source: CERL, EIFS Subprogram

Table E-5.6.3.2

VALLEY COUNTY ANNUAL AVERAGES

YEAR	LABOR FORCE	EMPLOYMENT	UNEMPLOYMENT	UNEMPLOYMENT RATE
1977	4,844	4,419	425	8.8
1976	5,144	4,704	440	8.6
1975	5,254	4,859	395	7.5
1974	5,447	5,144	303	5.6
1973	5,027	4,726	301	6.0
1972	5,037	4,784	253	5.0
1971	4,568	4,276	292	6.4
1970	4,499	4,268	231	5.1

Source: Valley County Job Security Administration, November 1978.

Table E-5.6.3.3

UNEMPLOYMENT INSURANCE

Valley County, 1978

	Number	Amount of Payments
December 1977	678	$ 54,880.00
February 1978	743	56,608.13
March 1978	721	52,343.81
May 1978	242	16,364.64
June 1978	274	17,322.04
July 1978	263	16,310.34
August 1978	293	18,077.00
September 1978	125	9,706.54
Cumulative Jan. 78 - Sept. 78	3,855	$278,633.51

Source: Montana Employment and Labor Force, October 1978.

E-5.6.4 Income Averages (Valley County)

Personal income for Valley County was adjusted based on Consumer Price Index (1967=100). All dollar amounts are in thousands of dollars (see Table E-5.6.4.1)

Table E-5.6.4.1

YEAR	PERSONAL INCOME	ADJUSTED INCOME	CHANGE	DEVIATION	% DEVIATION
1965	48,863	51,697			
1966	55,046	56,642	4,945	5,212	10.082 %
1967	56,726	56,726	84	350	0.619 %
1968	43,805	42,053	-14,673	-14,406	-25.396 %
1969	41,631	37,926	-4,127	-3,860	-9.179 %
1970	46,070	39,620	1,694	1,961	5.171 %
1971	46,347	38,190	-1,430	-1,163	-2.937 %
1972	57,960	46,310	8,120	8.387	21.961 %
1973	79,113	59,493	13,183	13,450	29.043 %
1974	78,448	53,188	-6,305	-6,038	-10.150 %
1975	78,072	49,029	-4,159	-3,892	-7.317 %

Average Yearly Change:	-267
Maximum Historic Positive Deviation:	13,450
Maximum Historic Negative Deviation:	-14,406
Positive RTV:	29.043
Negative RTV:	-17.016

*The positive Rational Threshold Value (RTV) equals the largest positive percent deviation in the historical record. The negative RTV is 67 percent of the maximum historic negative deviation.

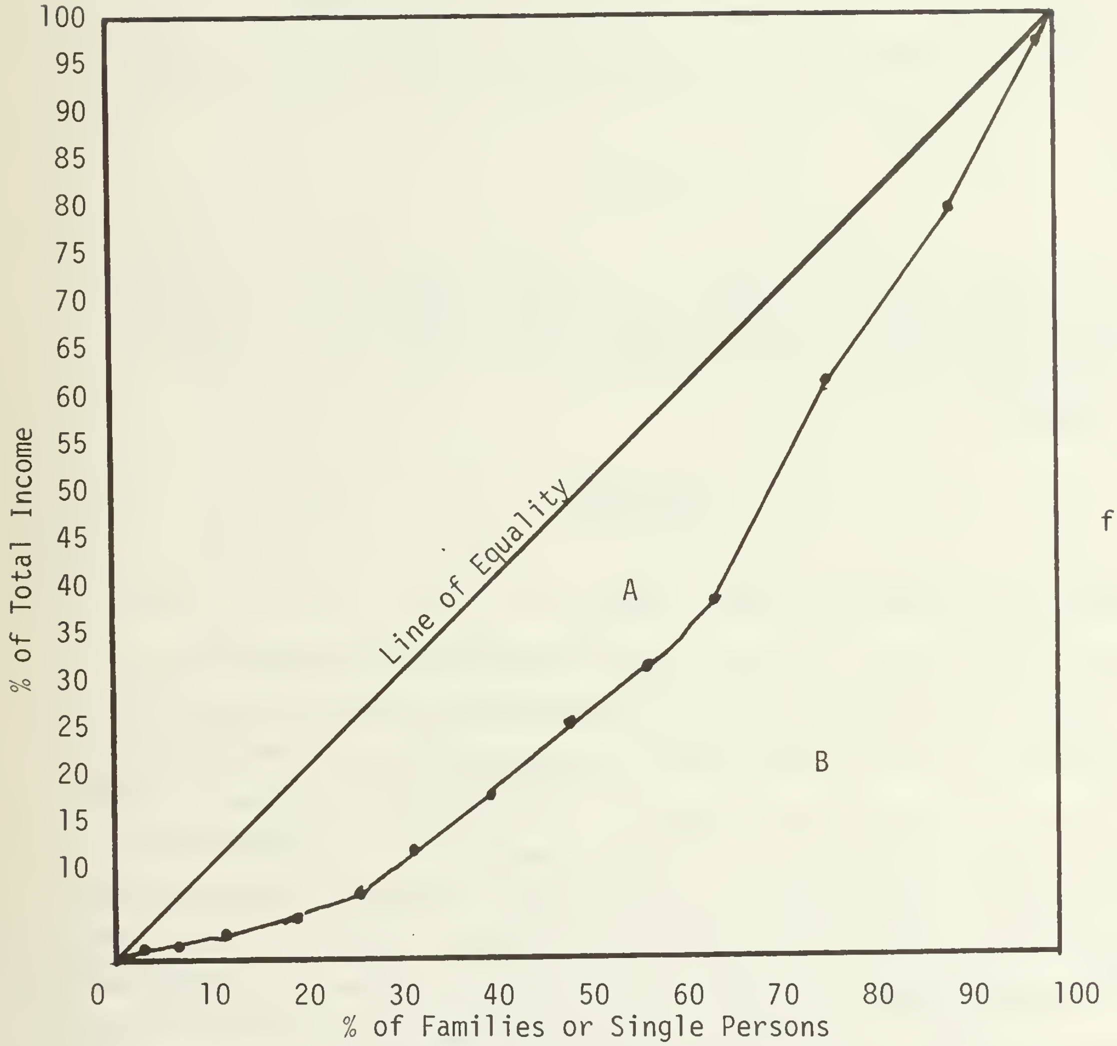
Source: CERL, EIFS Subprogram

INDEX OF INCOME CONCENTRATION

The index of income concentration is a statistical measure derived from the Lorenz Curve. The Lorenz Curve is obtained by plotting the cumulative percent of families on the abcissa against the cumulative percent of aggregate income accounted for by these families on the ordinate. If all families have exactly the same relative income, equality would be represented by the diagonal. Curves drawn to actual data fall below the line and the greater the inequality, the greater the area between the diagonal and the Lorenz Curve. The index of income concentration is the ratio of the area between the diagonal and the Lorenz Curve to the total area under the diagonal. The index of income concentration ranges from 0 to 1. As the index approaches the limit of 1, the greater the inequality of income distribution will be, (See Figure E-5.6.4.1).

(Figure E-5.6.4.1)

Lorenz Curve Plotted for Valley County



Curve derived from 1970 Census Data

Index of Income Concentration = $\frac{A}{A+B}$

= .325 Source: MERDI

From Montana Census Figures:

.335 for Rural Nonfarm

.439 for Rural Farm

Source: Bureau of Census, 1970 Census

E-5.7--CULTURAL

E-5.7.1 Archeological Surface Reconnaissance

In August 1978, MERDI contracted ECON, Helena, Montana to perform a cultural resource surface reconnaissance of GAFB which would consist of a literature review and an on-the-ground reconnaissance, looking for prehistoric and early historic manifestations on any exposed natural area on the base under Consulting Agreement Subcontract No. 8-13080-F.

The work was performed by Leslie B. Davis, Ph.D., assisted by Steve Aaberg, B.S. The lands considered on GAFB are legally described as:

T31N R40E

Sec. 18:SE¼, E½SW¼; Sec. 17:SW¼SW¼; Sec. 19:NE¼, NE¼NW¼; Sec. 20:NW¼, SE¼, S½NE¼, NW¼NE¼, N½SW¼, SE¼SW¼; Sec. 21:SW¼, SW¼NW¼, S½SE¼; Sec. 26: SW¼, S½SE¼; Sec. 27:NW¼, SW¼, SE¼, S½NE¼; Sec. 28:All; Sec. 29:NE¼NE¼; Sec. 32:NE¼, E½NW¼; Sec. 33:N½, SE¼, E½SW¼; Sec. 34:All; Sec. 35: N½, SW¼, N½SE¼

T30N R40E

Sec. 2:NW¼; Sec. 3:N½; Sec. 4:NE¼, E½NW¼

Of the 5,815 acres within the federal property boundaries, only certail areas around the periphery of the base are undeveloped and undisturbed (largely if not entirely). The undisturbed portion consists of upland prairie grasslands dissected by the occasional coulee or other erosional feature. Such terrain is most common in the northeast corner of the property. Some marshy areas are present along the north margin of the base. Three springs are especially prominent; two of the springs outlet into the system of coulees at the northeast corner of the property near the fifle range. The other spring lies below the easternmost sewage pond. The highest surface within the federal property is occupied by the runway and base-support facilities.

The upland surface occupied by the base consists of ground moraine deposited during the continental glaciation. This glacial surface has experienced little subsequent deposition. Some aeolian material and clays can be found around the property, however. Because of the age and nature of the parent surface, local cultural residues were expected to occur close to the surface. The sod cover is thick enough to obscure the old glacial surface, however, and any low-profile archaeological remains as well, i.e., scattered artifacts and lithic waste. While alluvium and colluvium have accumulated in the bottoms and along the slopes of coulees and breaks, alluvial terraces are lacking.

Initially, the north, west, and south perimeters of the base were driven to become familiar with access areas and to examine local surfaces. The vegetative cover of the undisturbed ground was extremely heavy. A dense carpet of club moss obscured the surface in many places. Needleleaf sedges are common and quite tall. Presumably, the natural vegetation has not been disturbed in these areas by grazing since activation of the base in 1955. Artificial seeding patterns and vegetational differences were usually visible on the ground, as supported by the supplied aerial infrared photographs of the base. Near the west end of the runway, dense growths of crested wheatgrass occur in disturbed tracts. Domestic species of vegetation also were abundant along the southern edge of the runway. An area of undeveloped prairie in the southern portion of the property just east of the sewage ponds had been disturbed by agriculture, grazing,and/or cultivation; however, native vegetation is re-establishing itself here. Some disturbance also was noted in the vicinity of the sanitary landfill. Portions of the base have been leased for agricultural use (grazing and cropping) since the facility was closed on June 30, 1978, particularly along the margins of the runway.

Archaeological sites occur occasionally along the extreme southern margin of the base but are more numerous along the east edge, with the highest density of sites located in the northeast corner of the property. Predictably, the spring-fed coulees and abutting uplands contain the most conspicuous and largest concentration of prehistoric features.

Telltale archaeological features consist of isles and closed circles of rock. Rockpiles occur singly in more-or-less isolated locations (function unknown), and in spaced linear sequence as single or multiple drive lines constructed to direct bison toward a killing place according to a defined plan of execution. Given the way in which such features are distributed in space, the designation of clustered features as a site or multiple sites is an arbitrary procedure. Multiple features are split, rather than lumped, where natural interruption of the surface segregate features on spatially separated landforms. Sites range in coverage from a few square meters of surface to extensive surfaces occupied by lengthy drive lines or a drive lane (two conjoining drive lines). Following this rationale, 16 prehistoric sites are differentiated. For initial purposes of identification and mapping, the sites are numbered GAFB-1 to GAFB-16.

All 16 sites are exposed on the surface and none appear to have any substantial buried aspect. Fifteen of the sites are comprised of rock features; only one is defined by the exclusive presence of lithic scatter. Six sites include one or more stone circles (tipi rings). Three sites are manifest as one or more drive lines. Three sites contain one or more rock piles. One rather indistinctly defined feature is designated as a rock cluster. A small rock-lined hearth with associated lithic debris also was recorded. An amorphous effigy boulder figure of indeterminate configuration also was located.

Most of the rock features located during the survey are subtle and unusually difficult to recognize as prehistoric features. Generally, they had been constructed of rather small rocks (or rocks little larger, in most instances, than the majority of buried but exposed rocks in the immediate vicinity). In addition to being low in profile, most of the sites are almost hidden by a heavy mantle of club moss and lichen. Although minor amounts of quartzite cobble debitage and occasional quartzite chopper were observed, none were collected. At many locations on the northern plains, surface artifacts are readily apparent and can be collected to provide meaningful information for interpretation. That is not the case on the base. Rockpiles that form cairns as singular features or as components of a drive system are often easily recognized and identified. On the base, they are difficult to locate. The cairns are generally flush with the vegetated surface, constructed of minimal rocks and widely spaced. The low-profile nature of these features is a result of geologic-climatic weathering processes acting on the small size of the rockpiles on weathering elevated surfaces.

The lack of chipped stone artifacts other than quartzite choppers and quartzite waste may reflect prior scouring of the surface by sheepherders, a common depletion agency in the Montana plains. Heavy surface cover could be concealing small-size artifacts. The present lack of time/culture diagnostic artifacts prohibits the reliable inference of age of prehistoric activities and occupational events reflected in the physical residues defined at 16 locations on the base; these are the only recorded archaeological sites known on the federal property. The cost of attempting to develop evidence that would put the recorded surficial structures into the time and cultural framework established for the Northwestern Plains would be high and not necessarily successful.

All known sites occur at some distance from areas developed for the runway and support facilities. Some sites can be considered close in but safe from disturbance by virtue of their location. Most of the sites are clustered in uneven dissected terrain where development has been limited or nonexistent. If future development is projected in locations where sites have been recorded care should be taken to avoid and prevent disturbance of known sites. If actions contemplated would adversely affect all or part of any site unavoidably, appropriate mitigation procedures should be implemented. All of the recorded sites, except for the lithic scatter, should receive attention if threatened by proposed development. The mitigation approach would properly involve two-dimensional mapping and test excavation followed by laboratory analysis and reporting if sites are to be eliminated.

The surface reconnaissance data do not suggest any of the sites are eligible for listing in the National Register of Historic Places. In the event one or more sites were to be destroyed, the preceding testing and sampling necessary for mitigation might possibly reveal additional data which would alter this opinion.

No previously published literature exists on sites at GAFB.

Application has been made to the University of Montana for Smithsonian site numbers. When these numbers become available they will be assigned to GAFB-1 through GAFB-16 and copies of the site report forms with the assigned numbers will be formally filed with the University of Montana.

Facsimiles of the Smithsonian Site Report Forms and 1:12,000 scale (1"=1,000') photo-gase topographic maps of GAFB with the site locations follow.

GAFB-1

MONTANA STATE UNIVERSITY

SITE NAME Runway SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE
2. TYPE OF SITE Habitation;Tipi Rings
3. CULTURAL AFFILIATION unknown prehistoric
4. LOCATION site lies on a ridge near the east end of the runway at the old Glasgow Air Base north of Glasgow, Montana.
NE¼SE¼ SEC. 27 T. 31N R. 40E
5. OWNER AND ADDRESS U.S. Government
6. PREVIOUS OWNERS
7. TENANT
8. INFORMANTS
9. PREVIOUS DESIGNATIONS FOR SITE
10. SITE DESCRIPTION site consists of 1 complete ring and 1 partial ring which lie on a ridge at the head of a coulee which drains eastward into Porcupine Creek. The features are very deeply sodded. No artifactual remains could be seen in the heavy grass cover.
11. POSITION OF SITE AND SURROUNDINGS A large coulee which is fed by several small spring coulees lies east of the site and drains into Porcupine Creek about 1.6 miles to the east.
12. AREA OF OCCUPATION .25 acre
13. DEPTH AND CHARACTER OF FILL a heavy cover of prairie grasses blankets the site area
14. PRESENT CONDITION undisturbed
15. PREVIOUS EXCAVATIONS
16. MATERIAL COLLECTED
17. MATERIAL OBSERVED 1 complete and 1 partial tipi ring
18. MATERIAL REPORTED AND OWNER
19. RECOMMENDATIONS FOR FURTHER WORK the rings should be mapped and excavated if the site area becomes subject to development
20. PHOTOGRAPH NO.
21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 8, 1978

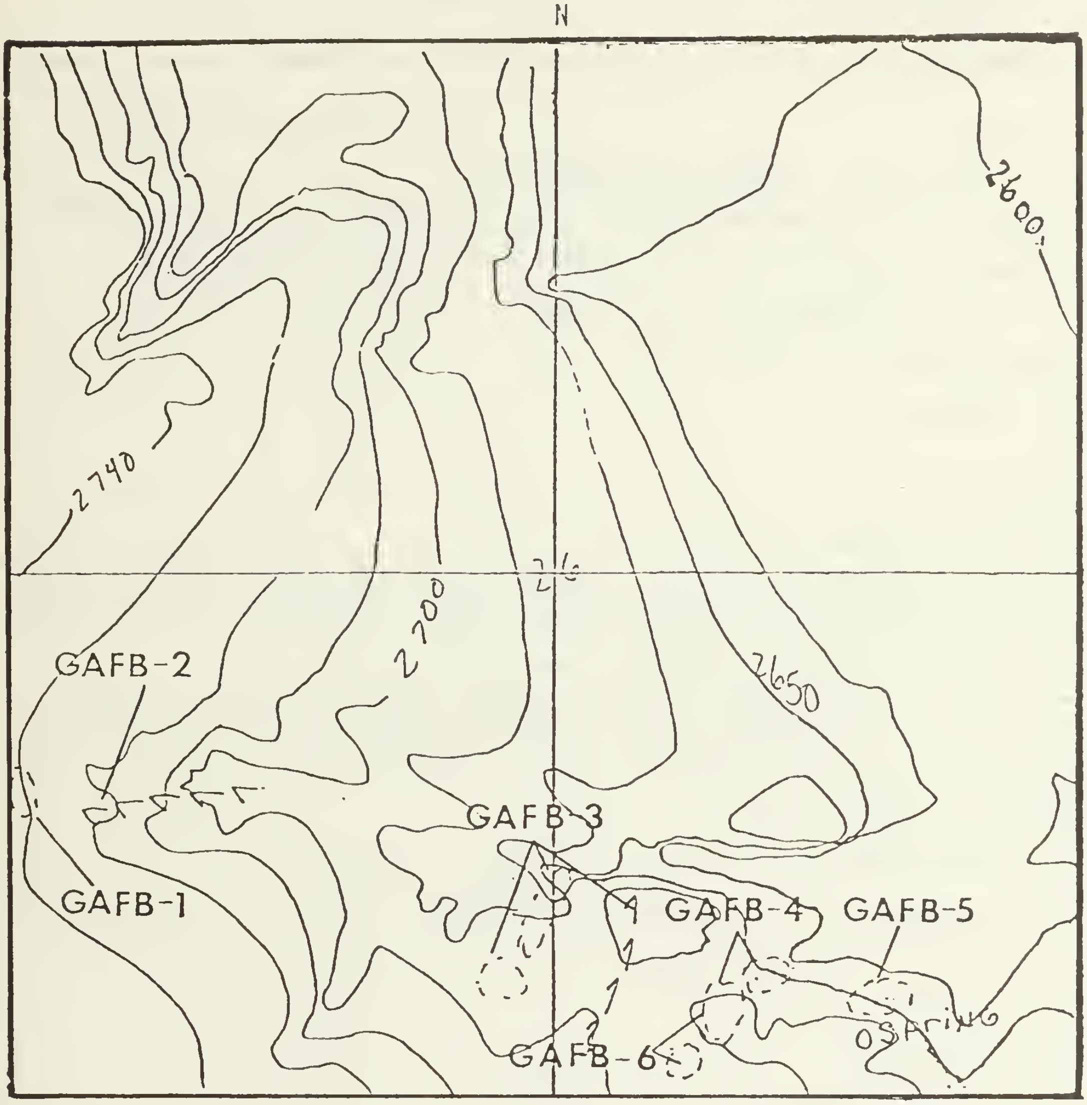
STATE Montana

COUNTY Valley

SITE NAME Runway

SITE NO.

SITE NO.________________ MAPPED BY________________ DATE__________



SCALE________________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-2

MONTANA STATE UNIVERSITY

SITE NAME Runway Reservoir Drive Line SITE NO.

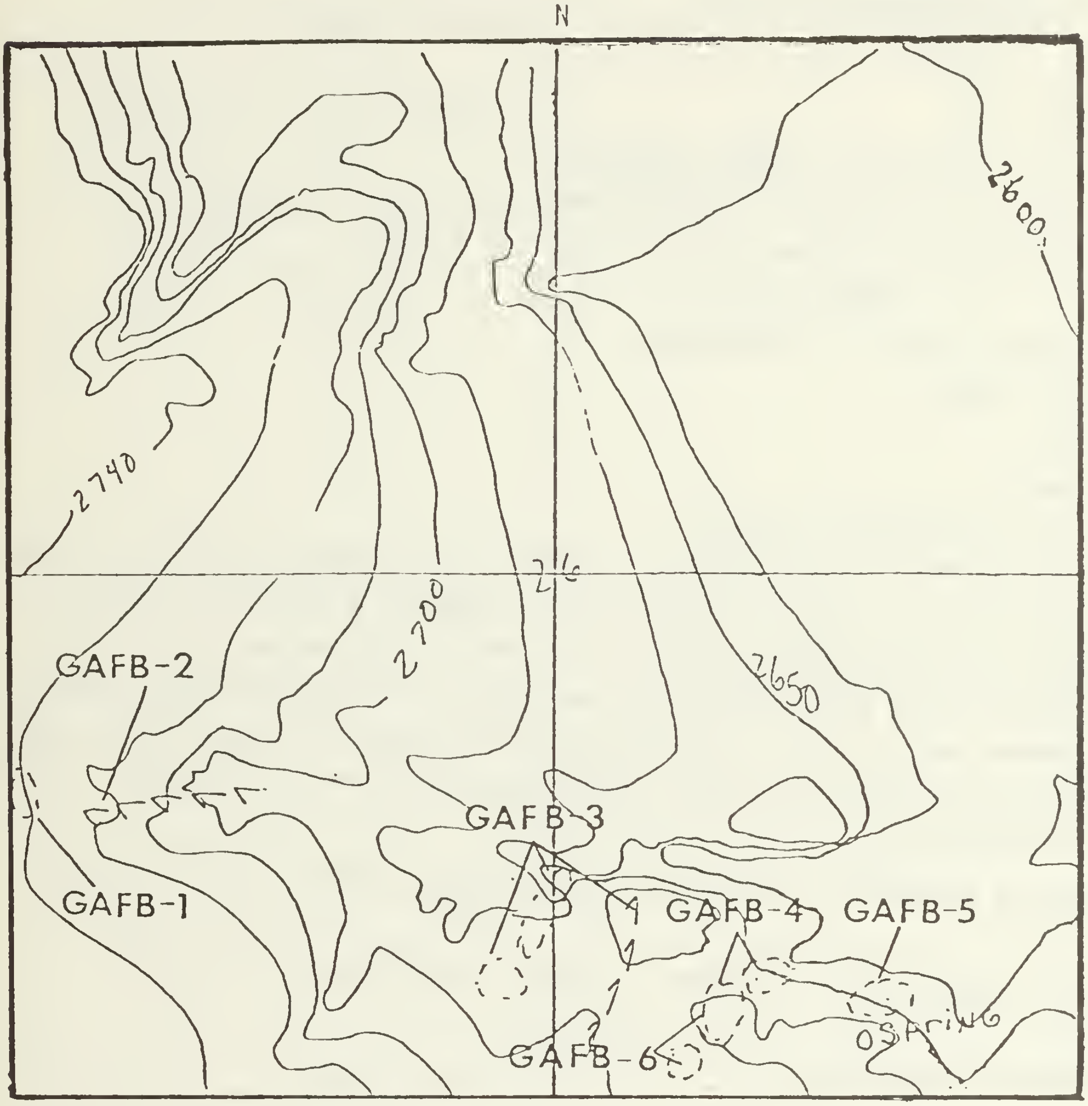
STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Drive Line
3. CULTURAL AFFILIATION unknown prehistoric
4. LOCATION site lies at the west end of a small reservoir near the east end of the runway at the old Glasgow Air Base north of Glasgow, Montana.
NW¼SW¼ SEC. 26 T. 31 N R. 40 E
5. OWNER AND ADDRESS U.S. Government
6. PREVIOUS OWNERS
7. TENANT
8. INFORMANTS
9. PREVIOUS DESIGNATIONS FOR SITE
10. SITE DESCRIPTION site consists of a single drive line segment which runs down a low ridge and enters a coulee now occupied by a reservoir. The piles which form the line are heavily sodded and low profile.
11. POSITION OF SITE AND SURROUNDINGS The alighment runs east-west. A large coulee heads in the vicinity of the site and drains eastward into Porcupine Creek some 1.5 miles distant.
12. AREA OF OCCUPATION
13. DEPTH AND CHARACTER OF FILL site restricted to surface
14. PRESENT CONDITION undisturbed
15. PREVIOUS EXCAVATIONS
16. MATERIAL COLLECTED
17. MATERIAL OBSERVED drive line
18. MATERIAL REPORTED AND OWNER
19. RECOMMENDATIONS FOR FURTHER WORK drive line should be mapped and photographed if the site locale is planned for development
20. PHOTOGRAPH NO.
21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 8, 1978

STATE Montana COUNTY Valley SITE NAME Runway Reservoir Drive Line SITE NO.

SITE NO.______________________ MAPPED BY______________ DATE________



SCALE______________________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-3

MONTANA STATE UNIVERSITY

SITE NAME Rifle Range Drive Lines SITE NO.

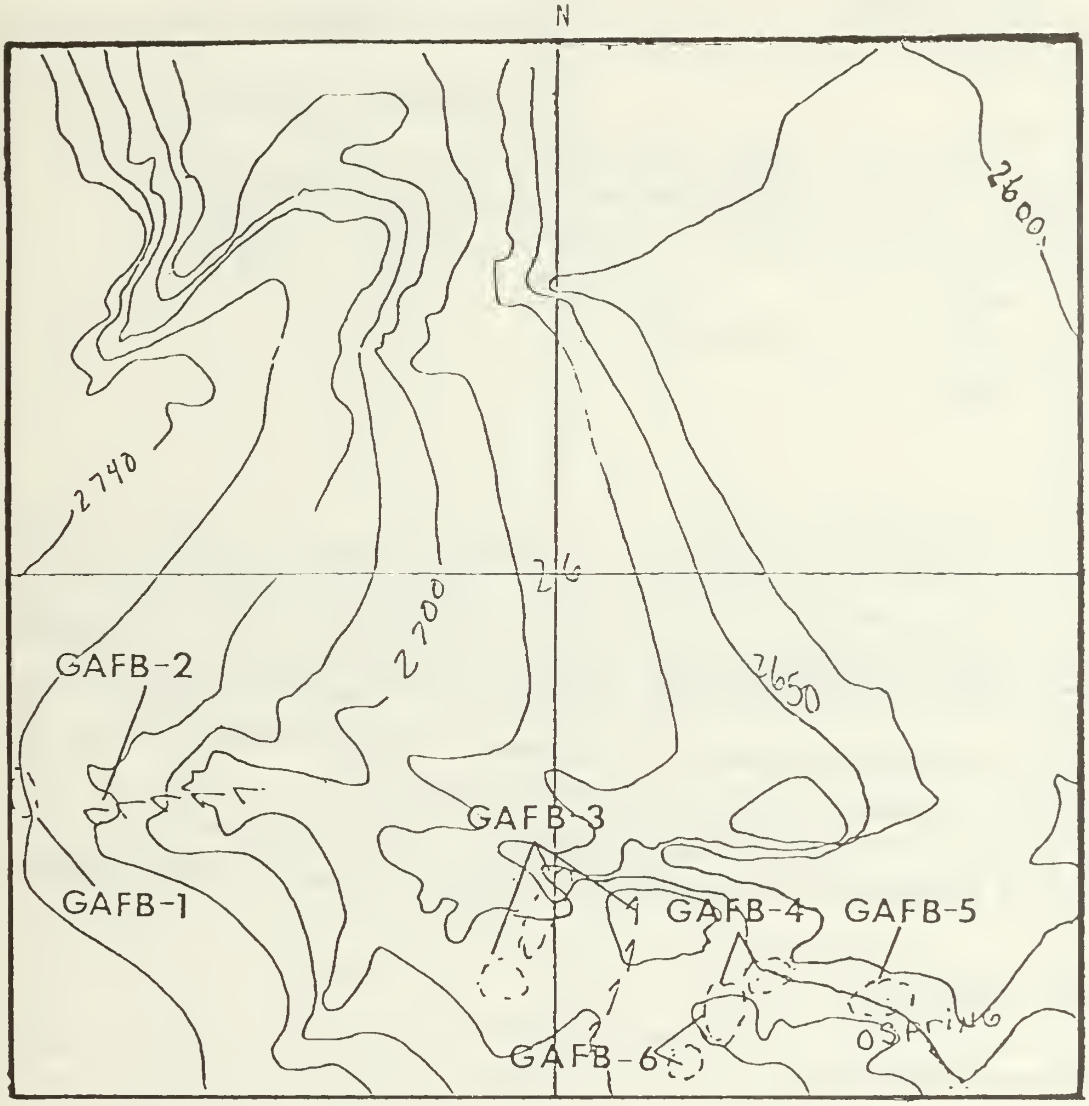
STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Drive Lines
3. CULTURAL AFFILIATION unknown prehistoric
4. LOCATION site lies west of the abandoned rifle range on the old Glasgow Air Base north of Glasgow, Montana
   SE¼SW¼, SW¼SE¼ SEC. 26 T. 31 N R. 40 E
5. OWNER AND ADDRESS U.S. Government
6. PREVIOUS OWNERS
7. TENANT
8. INFORMANTS
9. PREVIOUS DESIGNATIONS FOR SITE
10. SITE DESCRIPTION site consists of 2 drive line segments which run down the opposite sides of a small coulee. The alignments run down ridge tops and disappear in the large coulee into which the smaller coulee runs.
11. POSITION OF SITE AND SURROUNDINGS The large coulee mentioned above widens and deepens as it drains toward Porcupine Creek about 1.5 miles to the east. Several spring fed coulees enter this large coulee just east of the drive lines.
12. AREA OF OCCUPATION
13. DEPTH AND CHARACTER OF FILL site is restricted to the surface
14. PRESENT CONDITION drive lines are heavily sodded and low profile
15. PREVIOUS EXCAVATIONS
16. MATERIAL COLLECTED
17. MATERIAL OBSERVED 2 segments of drive lines
18. MATERIAL REPORTED AND OWNER
19. RECOMMENDATIONS FOR FURTHER WORK drive lines should be mapped and photographed if the area is scheduled for development
20. PHOTOGRAPH NO.
21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 8, 1978

STATE Montana COUNTY Valley SITE NAME Rifle Range Drive Lines SITE NO.

SITE NO.________________ MAPPED BY________________ DATE__________



SCALE____

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-4

MONTANA STATE UNIVERSITY

SITE NAME Spring Effigy SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Effigy

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies on a ridge 275m west of a developed spring on the old Glasgow Air Base north of Glasgow, Montana.

SW¼SE¼ SEC. 26 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION the site consists of a poorly defined rock feature which appears to be an effigy configuration of some sort. The feature appears to have a southeast-northwest orientation if the effigy is interpreted to be an anthropomorthic figure. Quartzite debris also was evident in the vicinity of the effigy.

11. POSITION OF SITE AND SURROUNDINGS site lies on a ridge which overlooks a series of spring fed coulees to the north and east. Extensive upland flats lie west and south. Porcupine Creek lies 1.5 miles to the east.

12. AREA OF OCCUPATION 2.5 acres including area with lithic scatter

13. DEPTH AND CHARACTER OF FILL site restricted to the glacial gravel surface

14. PRESENT CONDITION

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED effigy and lithic debris

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK effigy should be mapped and photographed if the site area becomes subject to development

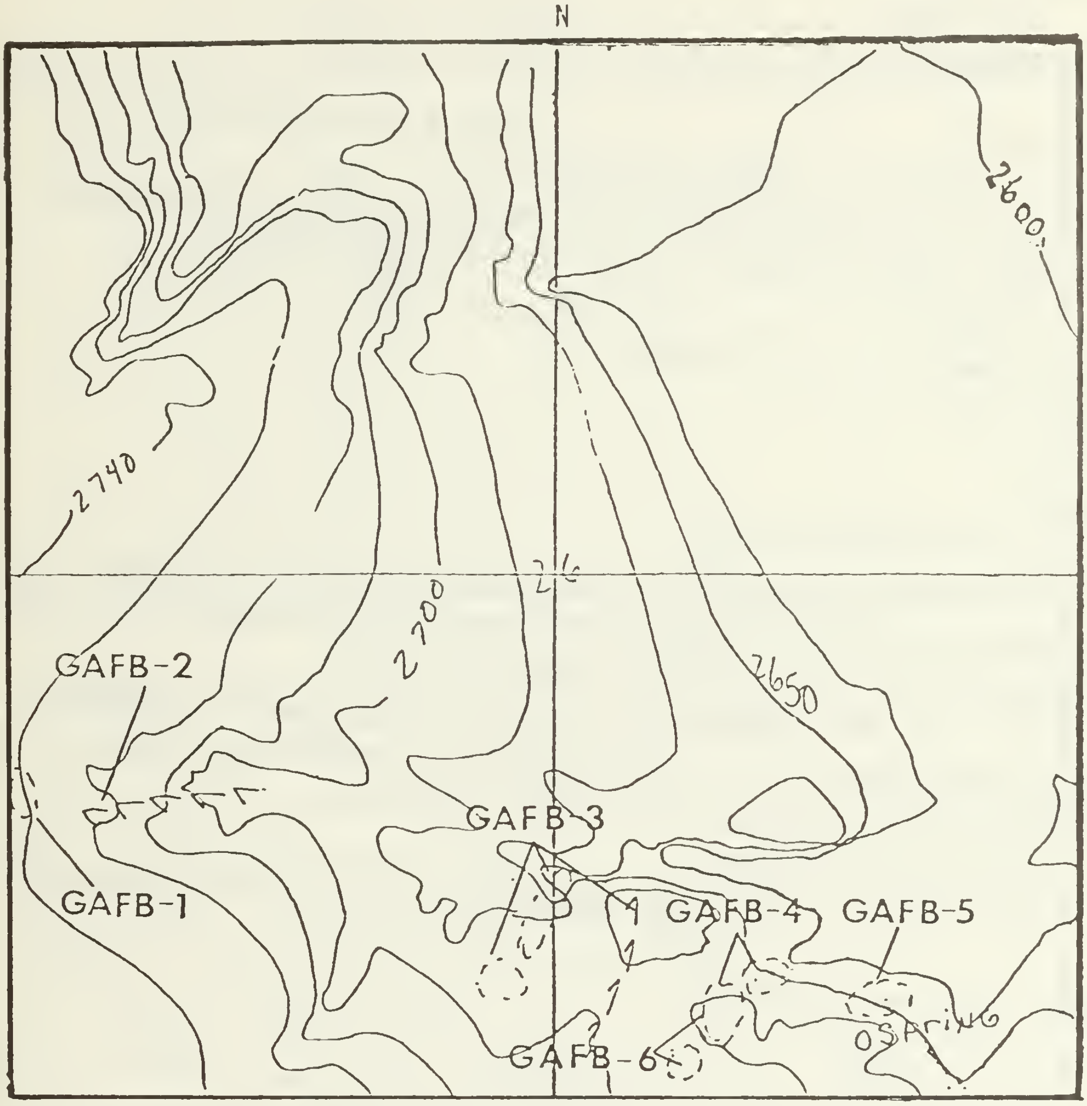
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 8, 1978

STATE Montana COUNTY Valley SITE NAME Spring Effigy SITE NO.

SITE NO.____________________ MAPPED BY____________________ DATE__________



SCALE____

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-5

MONTANA STATE UNIVERSITY

SITE NAME Spring Head SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Habitation

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies just north of the developed spring near the abandoned rifle range on the old Glasgow Air Base north of Glasgow, Montana.

SE¼SE¼ SEC. 26 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION site consists of a moderate scatter of quartzite debris and fire-cracked rock which are situated on a terrace on the north side of a coulee. A developed spring lies on the south side of the site.

11. POSITION OF SITE AND SURROUNDINGS Site materials are exposed in deflated areas on the surface. The spring fed coulee runs down the south side of the site while the main coulee lies 350m to the north.

12. AREA OF OCCUPATION 4 acres

13. DEPTH AND CHARACTER OF FILL site is restricted to the glacial gravel surface

14. PRESENT CONDITION undisturbed

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED lithic debris and fire-cracked rock

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK none

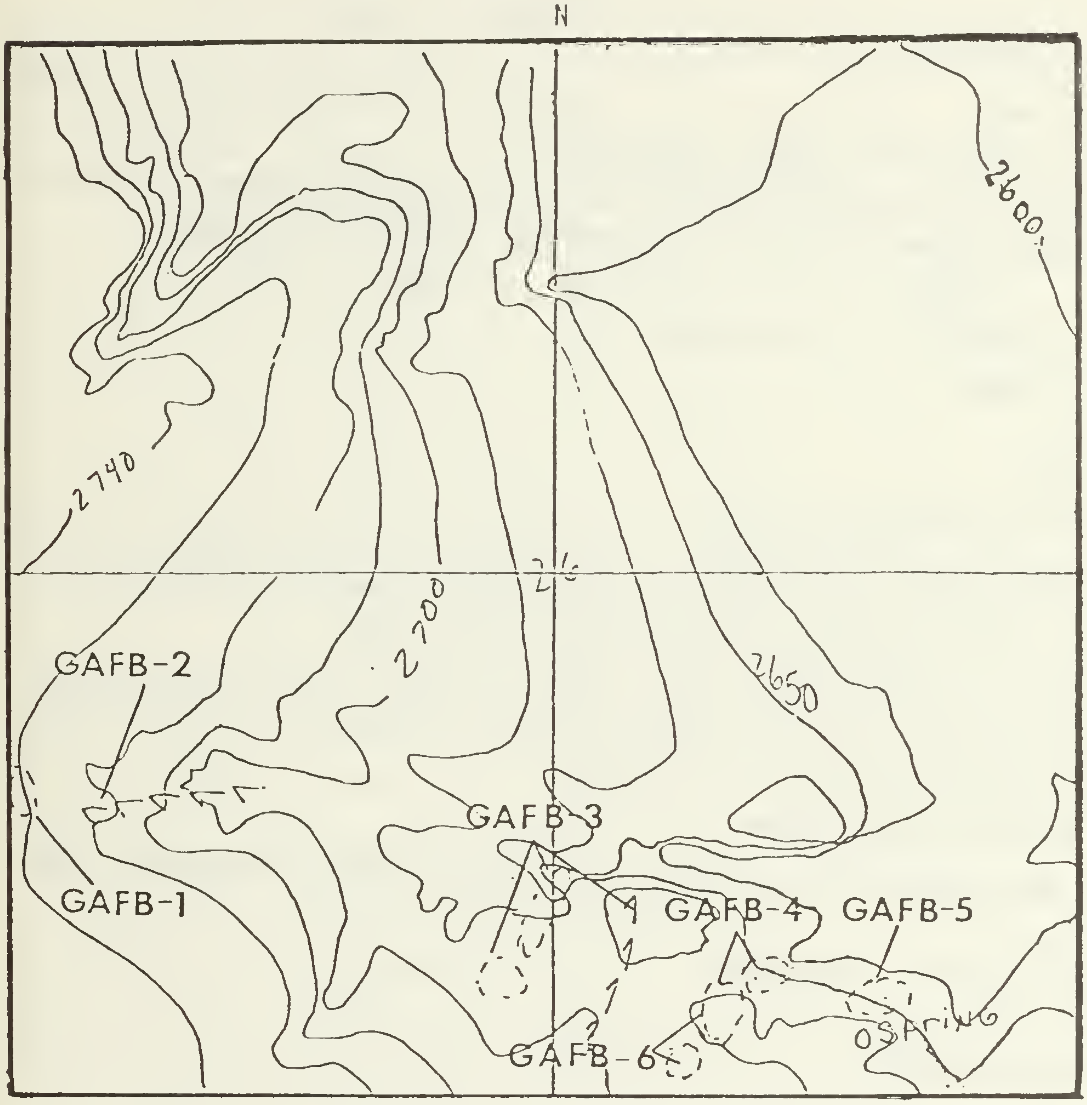
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME Spring Head SITE NO.

SITE NO.________________ MAPPED BY____________ DATE________



SCALE________________________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-6

MONTANA STATE UNIVERSITY

SITE NAME SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Habitation; Tipi Ring

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies near the northeast corner of the old Glasgow Air Base north of Glasgow, Montana. The old rifle range lies 250m to the northeast.

SW¼SE¼ SEC. 26 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION site consists of a single ring and cairn which lie on a ridge near the head of a small coulee. Both features are heavily sodded and low profile. Some quartzite debris was evident around them.

11. POSITION OF SITE AND SURROUNDINGS A series of coulees lie north and east of the site and they trend down to the Porcupine Creek about 1.5 miles to the east. An active spring lies 300 m east.

12. AREA OF OCCUPATION .25 acre

13. DEPTH AND CHARACTER OF FILL site is restricted to the glacial gravel surface

14. PRESENT CONDITION undisturbed

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED tipi ring and cairn

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK site should be mapped, photographed, and excavated if construction is planned for the site locale.

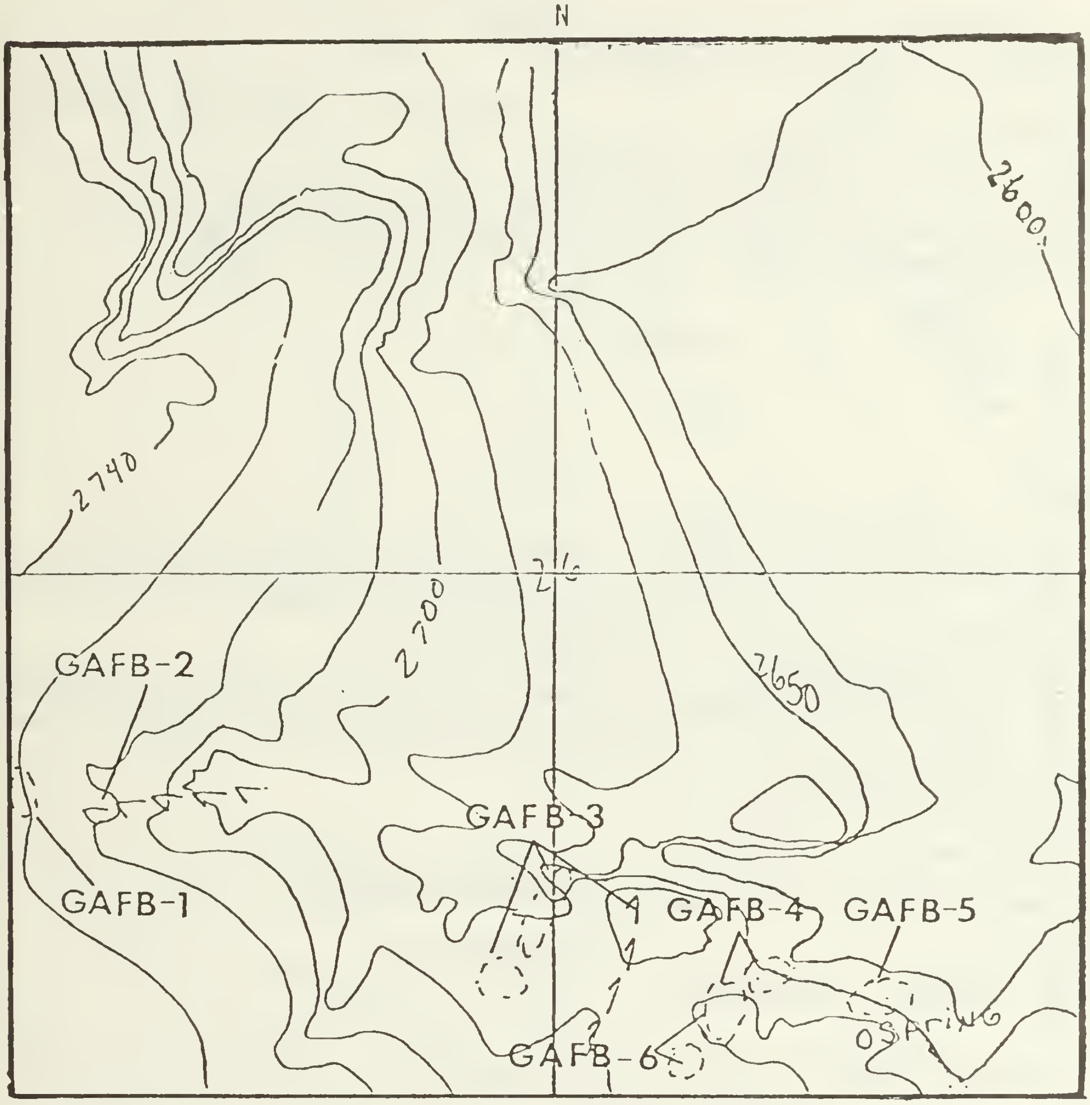
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME SITE NO.

SITE NO.________________ MAPPED BY________________ DATE__________



SCALE________________________________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-7

MONTANA STATE UNIVERSITY

SITE NAME SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Tipi Rings; Habitation

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies near the northeast corner of the old Glasgow Air Base north of Glasgow, Montana. The rifle range lies 250m to the northeast.

NW¼NE¼ SEC. 35 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION site consists of 3 tipi rings and 2 cairns and a light scatter of quartzite debris. The features are heavily sodded and low profile. The features are constructed of relatively small stones.

11. POSITION OF SITE AND SURROUNDINGS An active spring lies 225m to the northeast. A series of coulees also lie north and east and trend down to Porcupine Creek about 1.5 miles to the east.

12. AREA OF OCCUPATION 1 acre

13. DEPTH AND CHARACTER OF FILL site is restricted to the glacial grave; surface

14. PRESENT CONDITION undisturbed

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED tipi rings and cairns

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK site should be mapped, photographed, and excavated if the area is scheduled for development

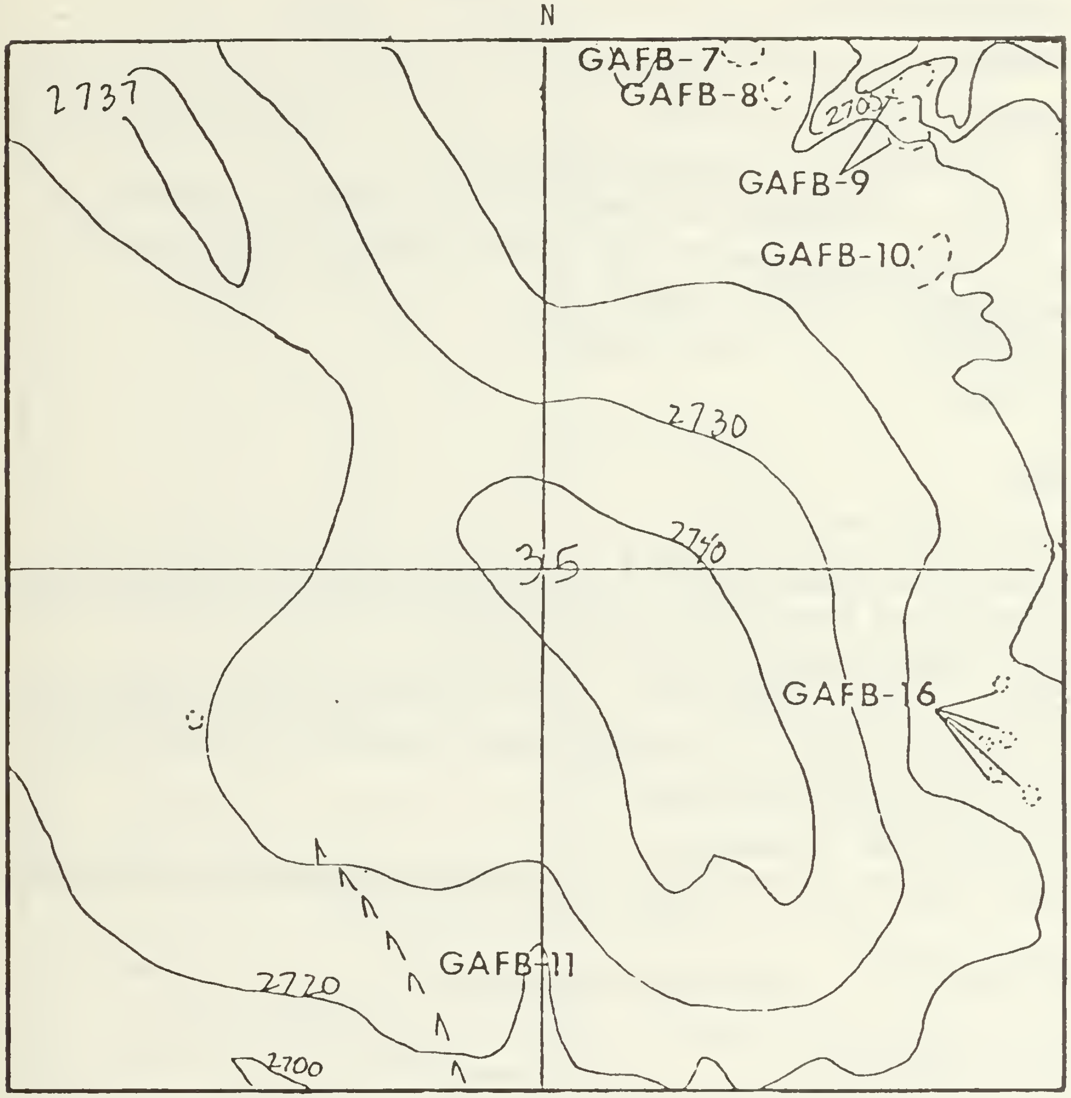
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME SITE NO.

SITE NO.________________ MAPPED BY________________ DATE________________



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SCALE____

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-8

MONTANA STATE UNIVERSITY

SITE NAME Northeast Trail SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Habitation; Tipi Rings

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies near the east edge of the old Glasgow Air Base north of Glasgow, Montana. It is located just north of a trail which runs to the northeast corner of federal property. SEC. 35 T. 31 N R. 40 E NW¼NE¼

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION site consists of 5 closely spaced tipi rings which are heavily sodded and inconspicuous. Some quartzite debris was present. The rings were formed from relatively small stones.

11. POSITION OF SITE AND SURROUNDINGS An active spring lies about 250m to the north and slightly east. A series of coulees lie north and east. Porcupine Creek lies 1.5 miles to the east.

12. AREA OF OCCUPATION 1 acre

13. DEPTH AND CHARACTER OF FILL site is restricted to the glacial gravel surface

14. PRESENT CONDITION undisturbed

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED Tipi Rings

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK the features should be mapped and excavated if the locality is ever scheduled for development.

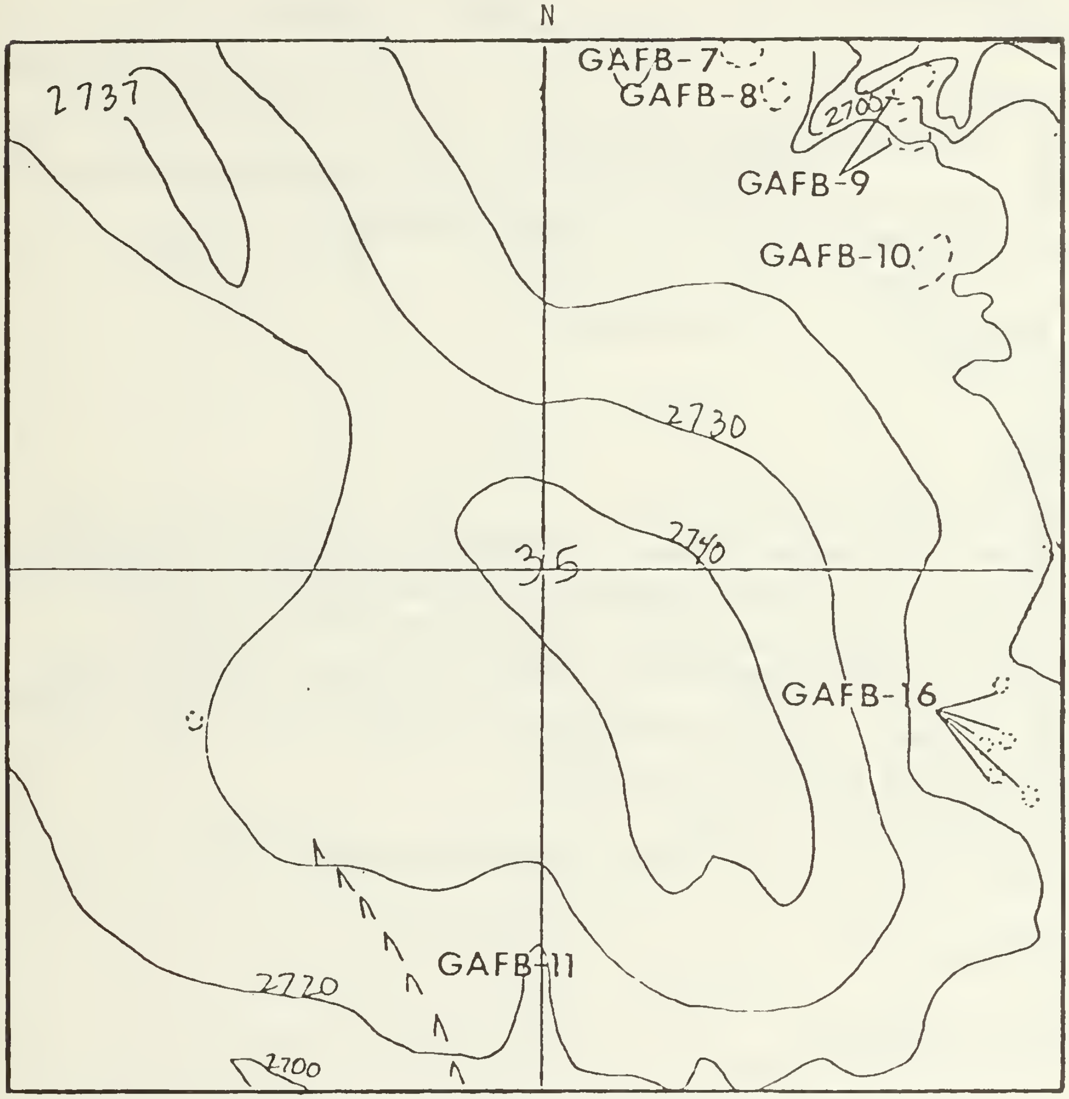
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME Northeast Trail SITE NO.

SITE NO.__________ MAPPED BY__________ DATE__________



SCALE__________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-9

MONTANA STATE UNIVERSITY

SITE NAME South Ridge SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Habitation; Tipi Rings

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies on the south side of a spring fed coulee on the east edge of the old Glasgow Air Base north of Glasgow, Montana

NE¼NE¼ SEC. 35 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION site consists of 4 tipi rings, one hearth (pile of fire-cracked rock), and a moderate scatter of quartzite debris. Site materials are situated on a narrow ridge bounded on the east and west by coulees.

11. POSITION OF SITE AND SURROUNDINGS A spring lies several coulees to the northwest (225m). The main coulee channel lies 300m to the north. Porcupine Creek lies about 1.25 mile to the east.

12. AREA OF OCCUPATION 3 acres

13. DEPTH AND CHARACTER OF FILL site is restricted to the surface

14. PRESENT CONDITION

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED tipi rings, fire-cracked rock, and quartzite debris.

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK map, photograph, and excavate, if the locality becomes subject to development

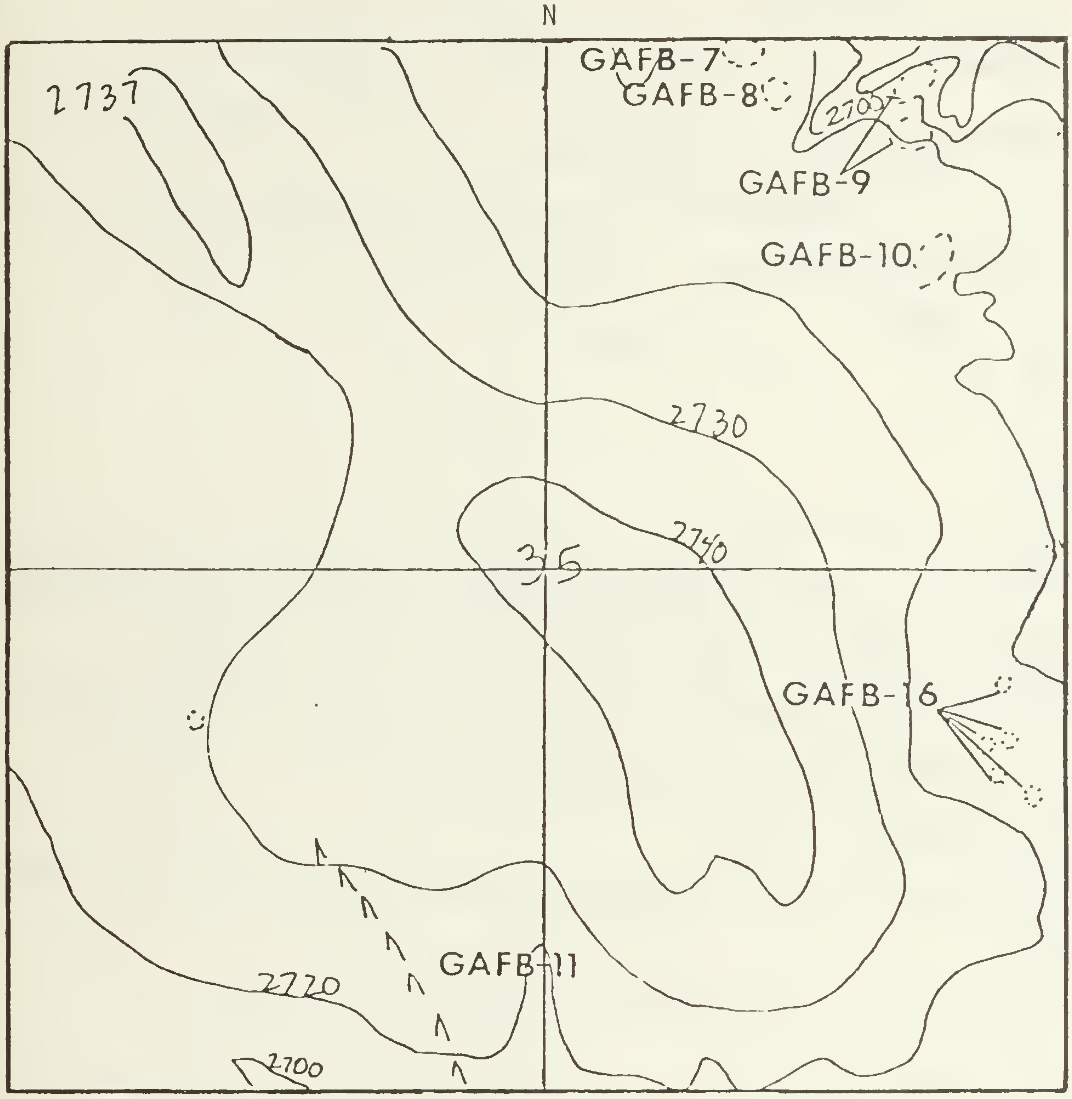
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME South Ridge SITE NO.

SITE NO.__________ MAPPED BY__________ DATE__________



SCALE__________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

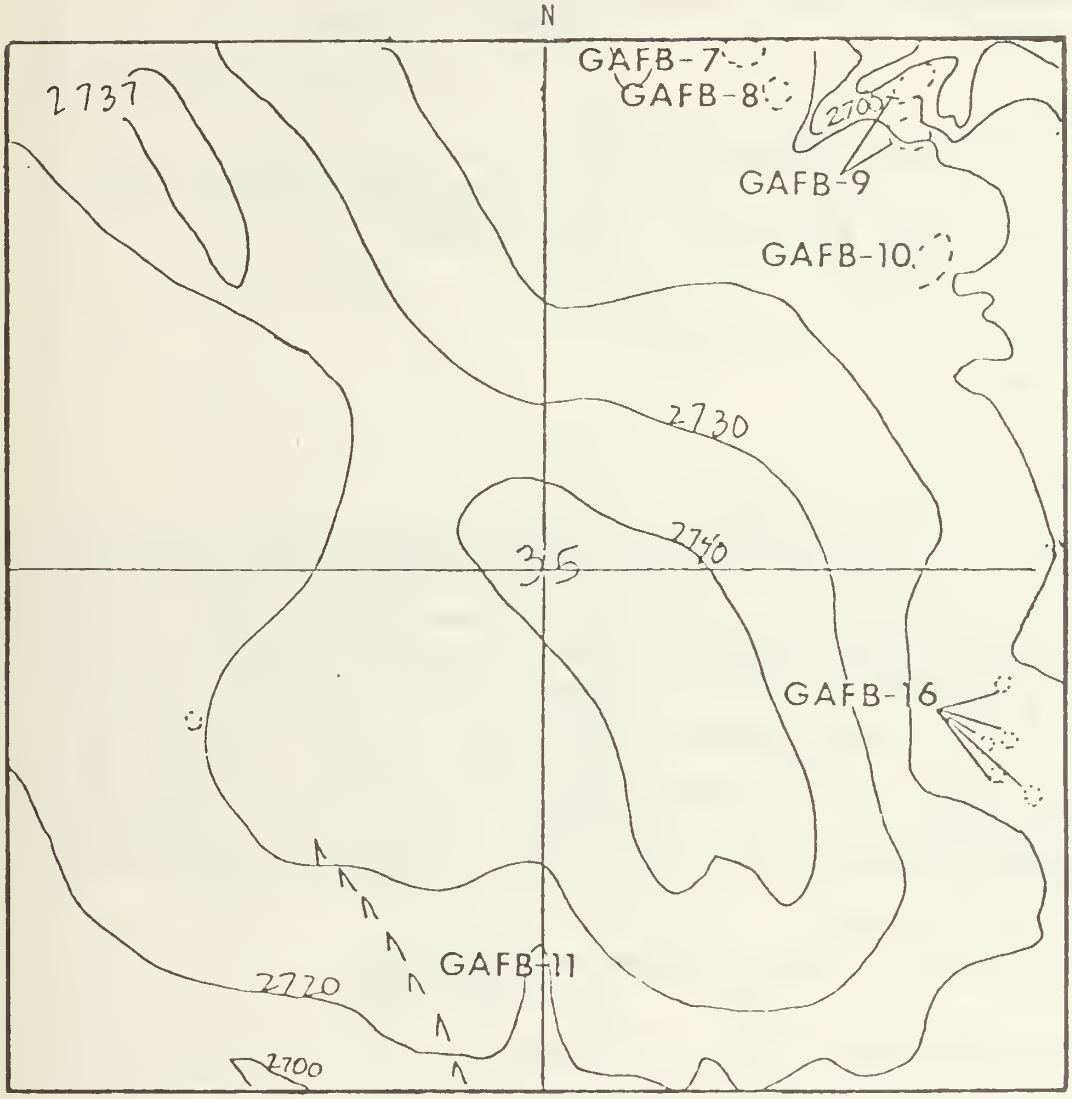
GAFB-10

MONTANA STATE UNIVERSITY
SITE NAME East Gate Rock Piles SITE NO.
STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Rock Piles
3. CULTURAL AFFILIATION unknown prehistoric
4. LOCATION site lies along the eastern boundary of the federal property at the old Glasgow Air Base north of Glasgow, Montana
NE¼NE¼ SEC. 35 T. 31 N R. 40 E
5. OWNER AND ADDRESS U.S. Government
6. PREVIOUS OWNERS
7. TENANT
8. INFORMANTS
9. PREVIOUS DESIGNATIONS FOR SITE
10. SITE DESCRIPTION 4 rock piles are situated on a series of ridges overlooking a coulee which trends to the east toward Porcupine Creek. The piles are heavily sodded and low profile. They are formed from softball size stones.
11. POSITION OF SITE AND SURROUNDINGS The site lies on the edge of the highest bluffs which overlook Porcupine Creek some 1 mile distant. The federal boundary fence adjoins the east edge of the site.
12. AREA OF OCCUPATION 5 acres
13. DEPTH AND CHARACTER OF FILL site is restricted to the old glacial gravel surface
14. PRESENT CONDITION undisturbed
15. PREVIOUS EXCAVATIONS
16. MATERIAL COLLECTED
17. MATERIAL OBSERVED rock piles
18. MATERIAL REPORTED AND OWNER
19. RECOMMENDATIONS FOR FURTHER WORK map and photograph the features if construction or disturbance is planned for the site locale.
20. PHOTOGRAPH NO.
21. MAPS OF SITE
RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME East of Rock Piles SITE NO.

SITE NO.____________________ MAPPED BY____________ DATE____________



SCALE____

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-11

MONTANA STATE UNIVERSITY

SITE NAME Air Base Drive Lines SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Drive Lines;Habitation

3. CULTURAL AFFILIATION unknown prehistoric

4. LOCATION site lies along the east boundary of the Federal property at the old Glasgow Air Force Base north of Glasgow, Montana
SE¼NW¼ Sec. 2 T30N R40E SEC. SW¼ 35 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION site consists of two seperate lengths of drive line visible on opposite sides of a coulee. The lines are formed from small, heavily sodded, and low profile cairns which are spaced on the average about 75m apart. The cairns run along the edge of a ridge top to the south and are visible again on a ridge across a coulee to the north.

11. POSITION OF SITE AND SURROUNDINGS A single isolated cairn lay north and west of the north drive line segment. Some quartzite debris was noted around some of the cairns or piles. Porcupine Creek and its south bluffs are visible to the north and east of the site.

12. AREA OF OCCUPATION The south segment is about 1/3 mile long while the north segment stretches for 1/4 mile.

13. DEPTH AND CHARACTER OF FILL site is restricted to on or near the glacial gravel surface.

14. PRESENT CONDITION heavily sodded and inconspicuous

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED drive line segments and quartzite debris

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK site should be mapped and photographed if it becomes endangered by development

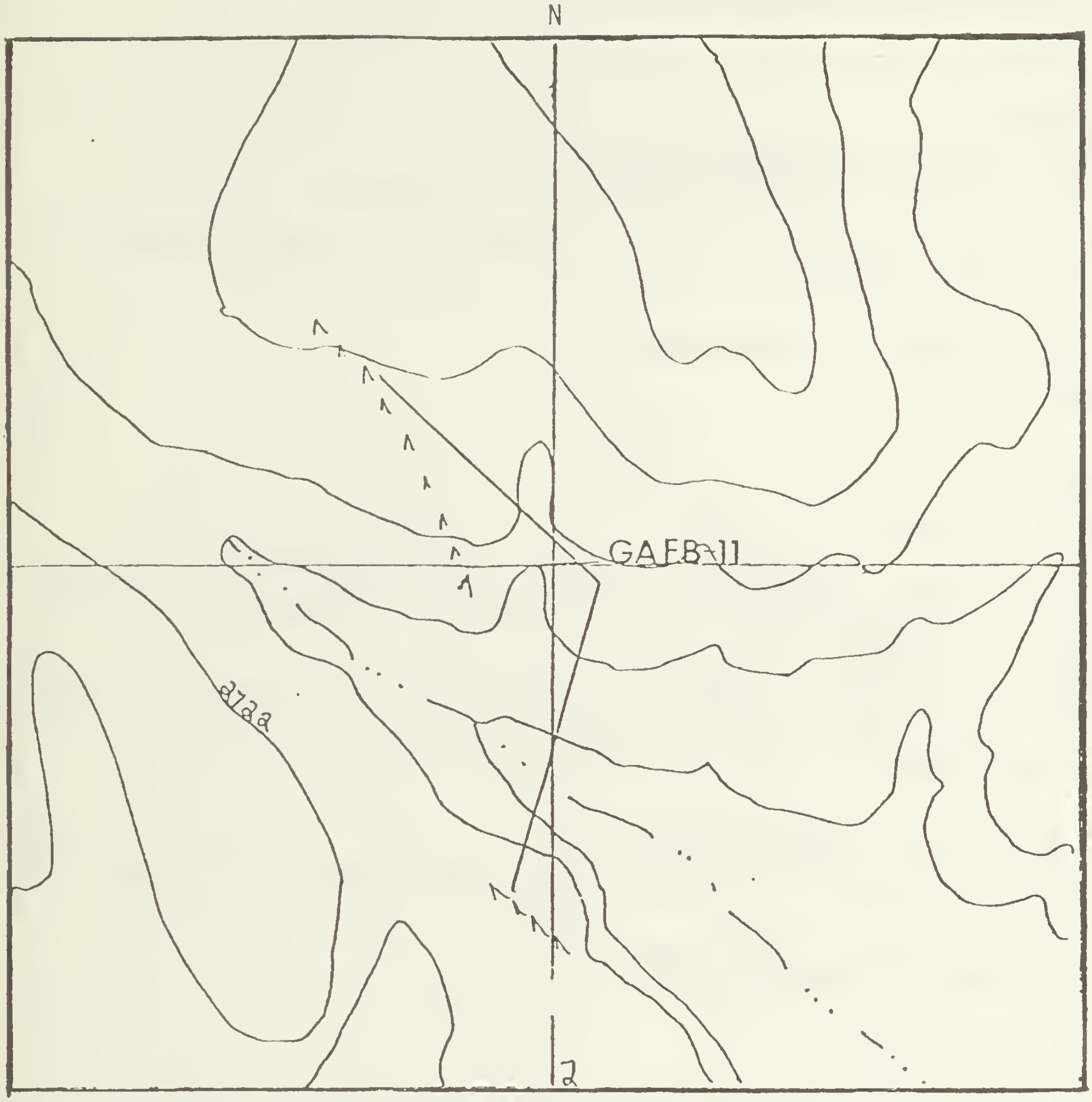
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE Sept. 7, 1978

STATE Montana COUNTY Valley SITE NAME Air Base Drive Lines SITE NO.

SITE NO.____________________ MAPPED BY________________ DATE____________



SCALE____

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-12

MONTANA STATE UNIVERSITY

SITE NAME Enright Rock Cluster SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Rock Cluster

3. CULTURAL AFFILIATION Unknown Prehistoric

4. LOCATION Site lies on the old Glasgow Air Force Base north of Glasgow, Montana. Site situated in the southeast corner of the Federal property.
SW 1/4 NW 1/4 SEC. 2 T. 30 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION Site consists of a cluster of grapefruit sized rocks about 1m in diameter. The feature is exposed in a deflated area where gravel lag deposits are visible.

11. POSITION OF SITE AND SURROUNDINGS Site lies on a gently sloping ridge about 375m north of Enright Coulee. A high flat ridge lies just north of the site.

12. AREA OF OCCUPATION Not applicable.

13. DEPTH AND CHARACTER OF FILL Site is restricted to the glacial gravel surface.

14. PRESENT CONDITION Weathered

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED Rock cluster.

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK The feature should be mapped and photographed if the area is ever scheduled for construction.

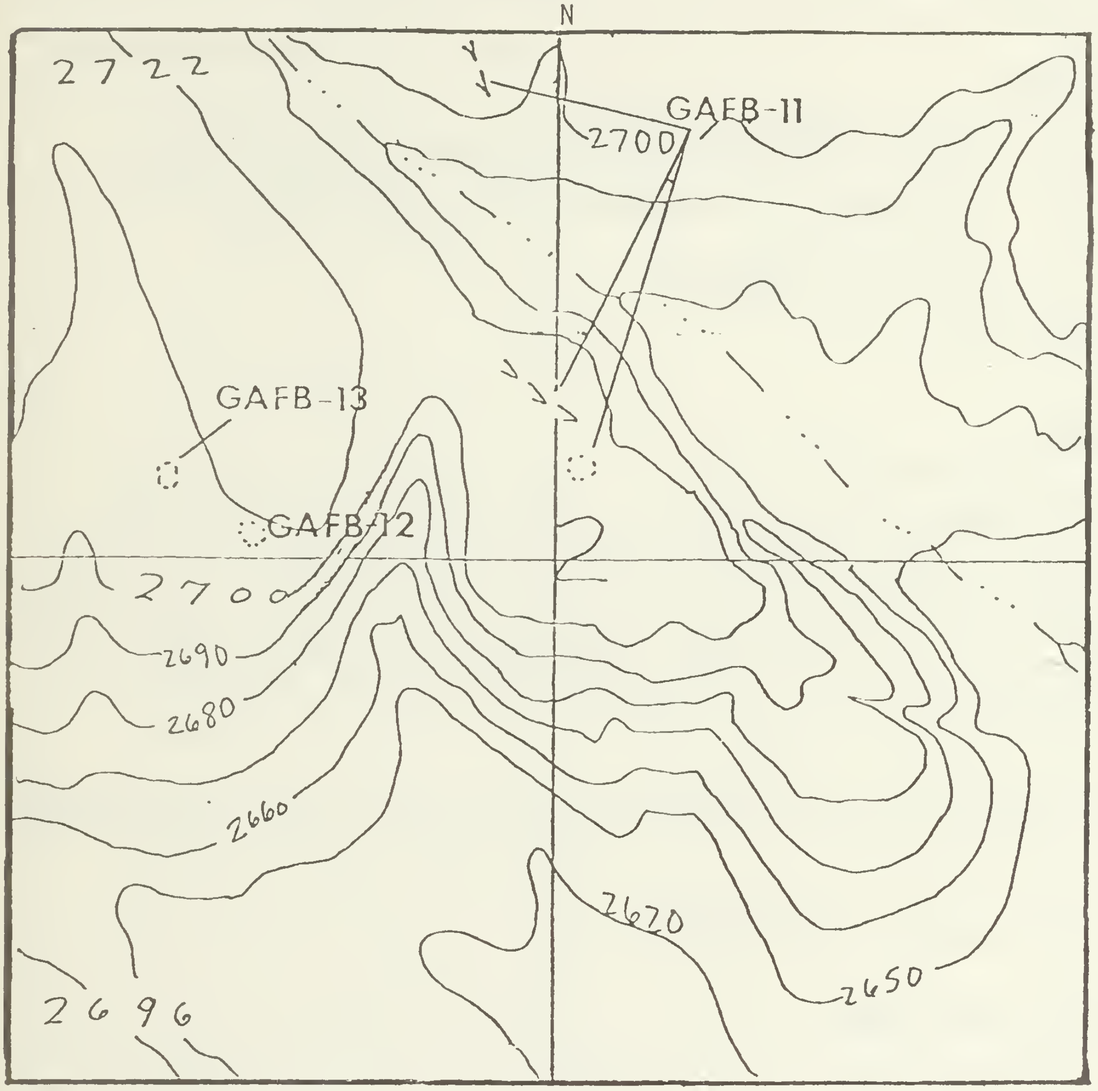
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE September 7, 1978

STATE Montana COUNTY Valley SITE NAME Enright RockCluster SITE NO.

SITE NO.____________________ MAPPED BY____________________ DATE__________



SCALE____
When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-13

MONTANA STATE UNIVERSITY

SITE NAME Enright Stone Pile SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Rock Feature (Pile)

3. CULTURAL AFFILIATION Unknown Prehistoric

4. LOCATION Site lies on the old Glasgow Air Force Base north of Glasgow, Montana. Site situated in the southeast corner of the Federal property.
SW 1/4 NW 1/4 SEC. 2 T. 30 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION Site consists of a large ovoid rock pile about 1.2 m long by .75 m wide. Most of the stones are the size of grapefruits and are moderately sodded and partially buried. No other cultural debris was evident.

11. POSITION OF SITE AND SURROUNDINGS The feature is situated on a gently sloping ridge which trends down to Enright Coulee about 400m to the south.

12. AREA OF OCCUPATION Not applicable.

13. DEPTH AND CHARACTER OF FILL Site is restricted to the glacial gravel surface.

14. PRESENT CONDITION Undisturbed.

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED Ovoid rock feature.

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK The feature should be photographed, mapped, and excavated if projected development would occur in the site vicinity.

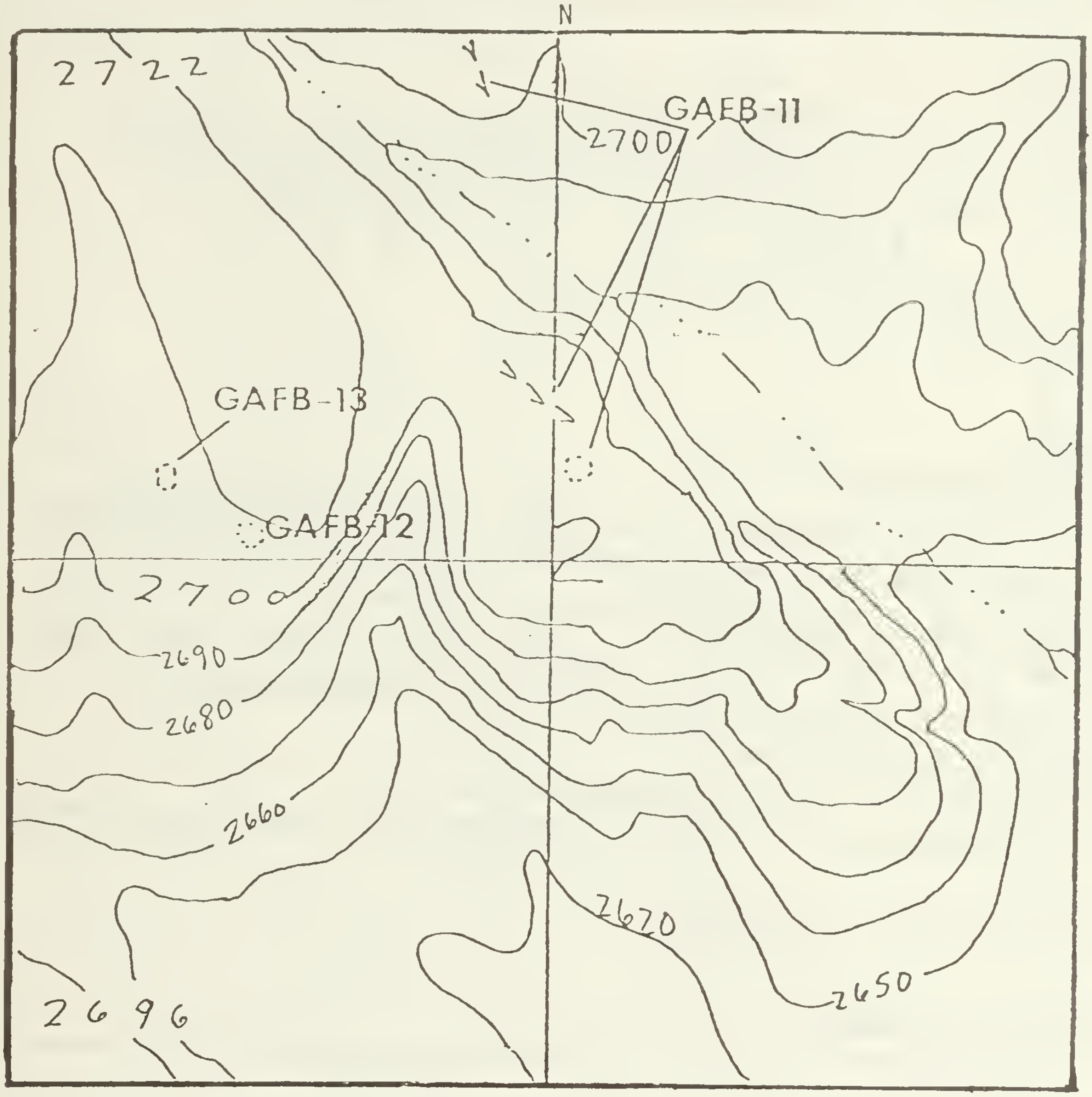
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg . DATE September 7, 1978.

STATE Montana
COUNTY Valley
SITE NAME Enright Rock Pile
SITE NO.

SITE NO.__________ MAPPED BY__________ DATE__________



SCALE__________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-14

MONTANA STATE UNIVERSITY

SITE NAME Aqueduct Hearth SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Habitation, Hearth

3. CULTURAL AFFILIATION Unknown Prehistoric.

4. LOCATION Site lies on the old Glasgow Air Force Base north of Glasgow, Montana. Hearth lies about 175m east of the aqueduct or water line.

NW 1/4 NE 1/4 SEC. 3 T. 30 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION Site consists of a single stone lined hearth with very little associated lithic debris. The hearth is roughly circular with a diameter of about 35cm. The stones are not fire-cracked.

11. POSITION OF SITE AND SURROUNDINGS The site lies on a gently sloping ridge which overlooks Enright Coulee to the south. A slightly higher level surface lies to the northeast.

12. AREA OF OCCUPATION Area of the hearth.

13. DEPTH AND CHARACTER OF FILL Site is restricted to the glacial gravel surface.

14. PRESENT CONDITION Undisturbed.

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED Stone lined hearth.

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK Photograph, map, and excavate in the event the site locale is scheduled for development.

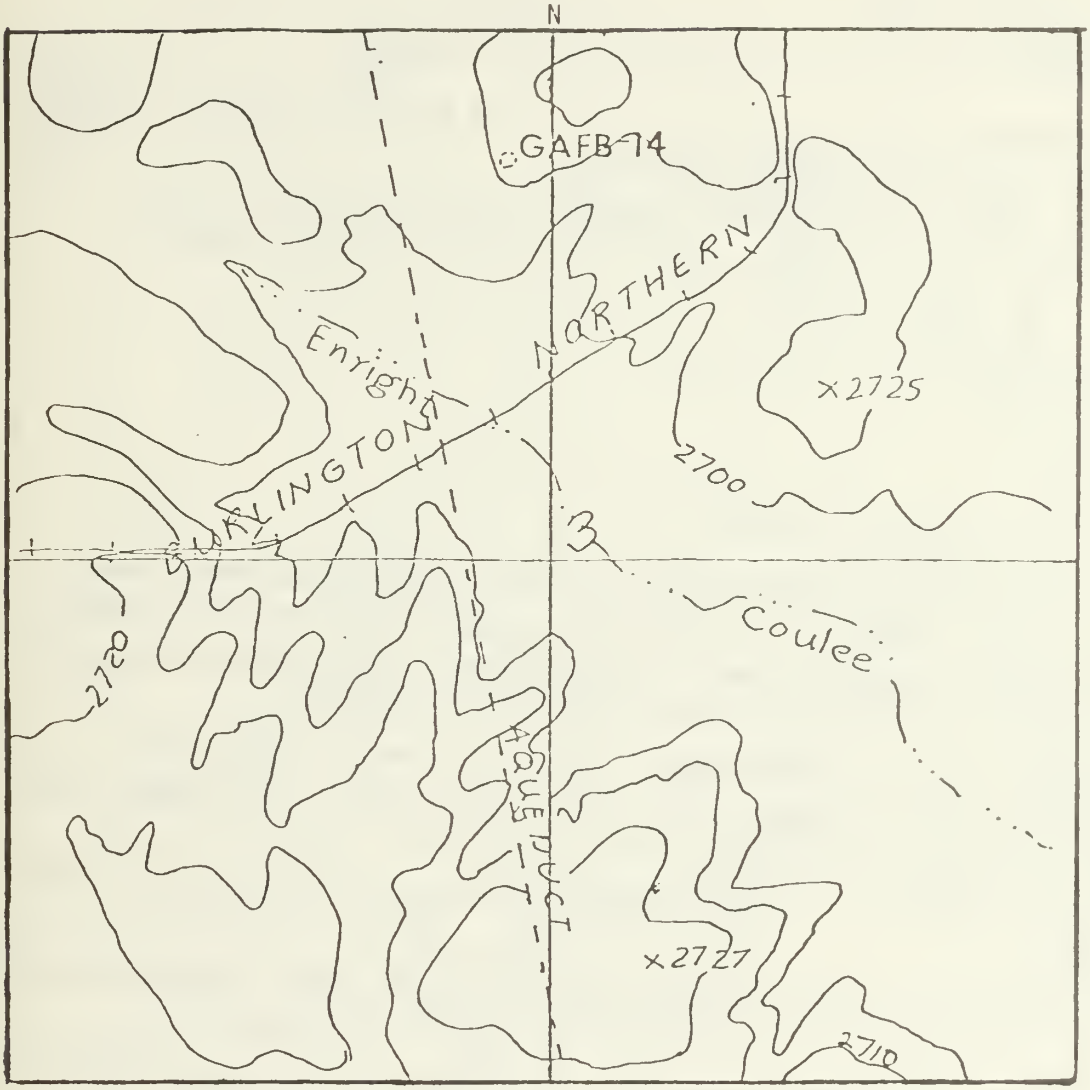
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE September 7, 1978

STATE Montana COUNTY Valley SITE NAME Aqueduct Hearth SITE NO.

SITE NO.____________________ MAPPED BY________________ DATE__________



SCALE____________________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

MONTANA STATE UNIVERSITY

SITE NAME Disposal Ponds SITE NO.

STATE Montana COUNTY Valley

1. MAP REFERENCE 2. TYPE OF SITE Hibatation Tipi Ring

3. CULTURAL AFFILIATION Unknown Prehistoric.

4. LOCATION Site lies on the old Glasgow Air Force Base north of Glasgow, Montana. Site is situated on ridge south of sewage disposal ponds.

SW 1/4 SW 1/4 NE 1/4 SEC. 4 T. 30 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS

7. TENANT

8. INFORMANTS

9. PREVIOUS DESIGNATIONS FOR SITE

10. SITE DESCRIPTION The site consists of 3 tipi rings and a moderate scatter of quartizite debris and fire-cracked rock. The rings were deeply sodded and partially scattered. Two of the rings were closely spaced while the third lay 50m to the southeast.

11. POSITION OF SITE AND SURROUNDINGS Site lies on a east-west trending ridge. The ridge commands a view in all directions except the south where a higher ridge rises. Spring Coulee lies 20m to the east.

12. AREA OF OCCUPATION Five acres.

13. DEPTH AND CHARACTER OF FILL Site appears restricted to the old glacial gravel surface.

14. PRESENT CONDITION Undisturbed, although some of the rings have been scattered.

15. PREVIOUS EXCAVATIONS

16. MATERIAL COLLECTED

17. MATERIAL OBSERVED 3 tipi rings, quartizite debris, and fire-cracked rock.

18. MATERIAL REPORTED AND OWNER

19. RECOMMENDATIONS FOR FURTHER WORK If development is planned for the site area, the rings should be mapped and excavated and a controlled surface collection made.

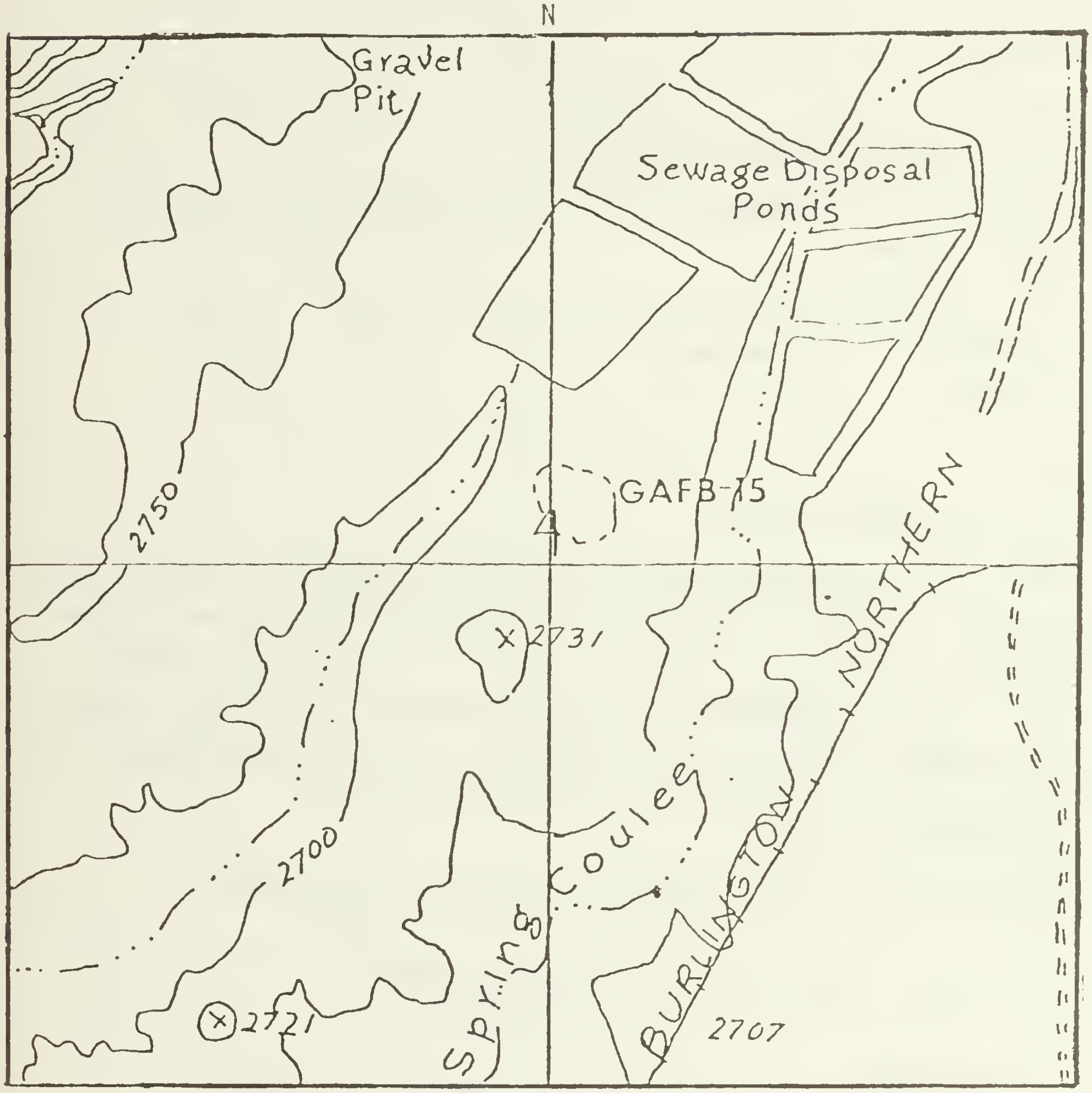
20. PHOTOGRAPH NO.

21. MAPS OF SITE

RECORDED BY Steve Aaberg DATE September 7, 1978

STATE Montana COUNTY Valley SITE NAME Disposal Ponds SITE NO.

SITE NO.______________________________MAPPED BY____________________DATE__________



SCALE____

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

GAFB-16

MONTANA STATE UNIVERSITY

SITE NAME ______ SITE NO. ______

STATE Montana COUNTY Valley

1. MAP REFERENCE ______ 2. TYPE OF SITE Rock Pile

3. CULTURAL AFFILIATION Unknown Prehistoric

4. LOCATION Site lies on the east edge of the Glasgow Air Force Base north of Glasgow, Montana.

NE 1/4 SE 1/4 SEC. 35 T. 31 N R. 40 E

5. OWNER AND ADDRESS U.S. Government

6. PREVIOUS OWNERS ______

7. TENANT ______

8. INFORMANTS ______

9. PREVIOUS DESIGNATIONS FOR SITE ______

10. SITE DESCRIPTION Site consists of 5 rock piles situated on a series of ridges which overlook a coulee. The coulee runs into Porcupine Creek which lies about 1.5 miles to the east. The piles are in no discernible alignment.

11. POSITION OF SITE AND SURROUNDINGS Site is surrounded by glacially sculpted prairie grassland. To the east and northeast are the rims and breaks which trend down to Porcupine Creek about 1-2 miles to the east.

12. AREA OF OCCUPATION 10 acres.

13. DEPTH AND CHARACTER OF FILL Site is restricted to the surface.

14. PRESENT CONDITION Undisturbed (very heavily sodded).

15. PREVIOUS EXCAVATIONS ______

16. MATERIAL COLLECTED ______

17. MATERIAL OBSERVED Rock piles.

18. MATERIAL REPORTED AND OWNER ______

19. RECOMMENDATIONS FOR FURTHER WORK If the site locale is scheduled for development the piles should be mapped and photographed.

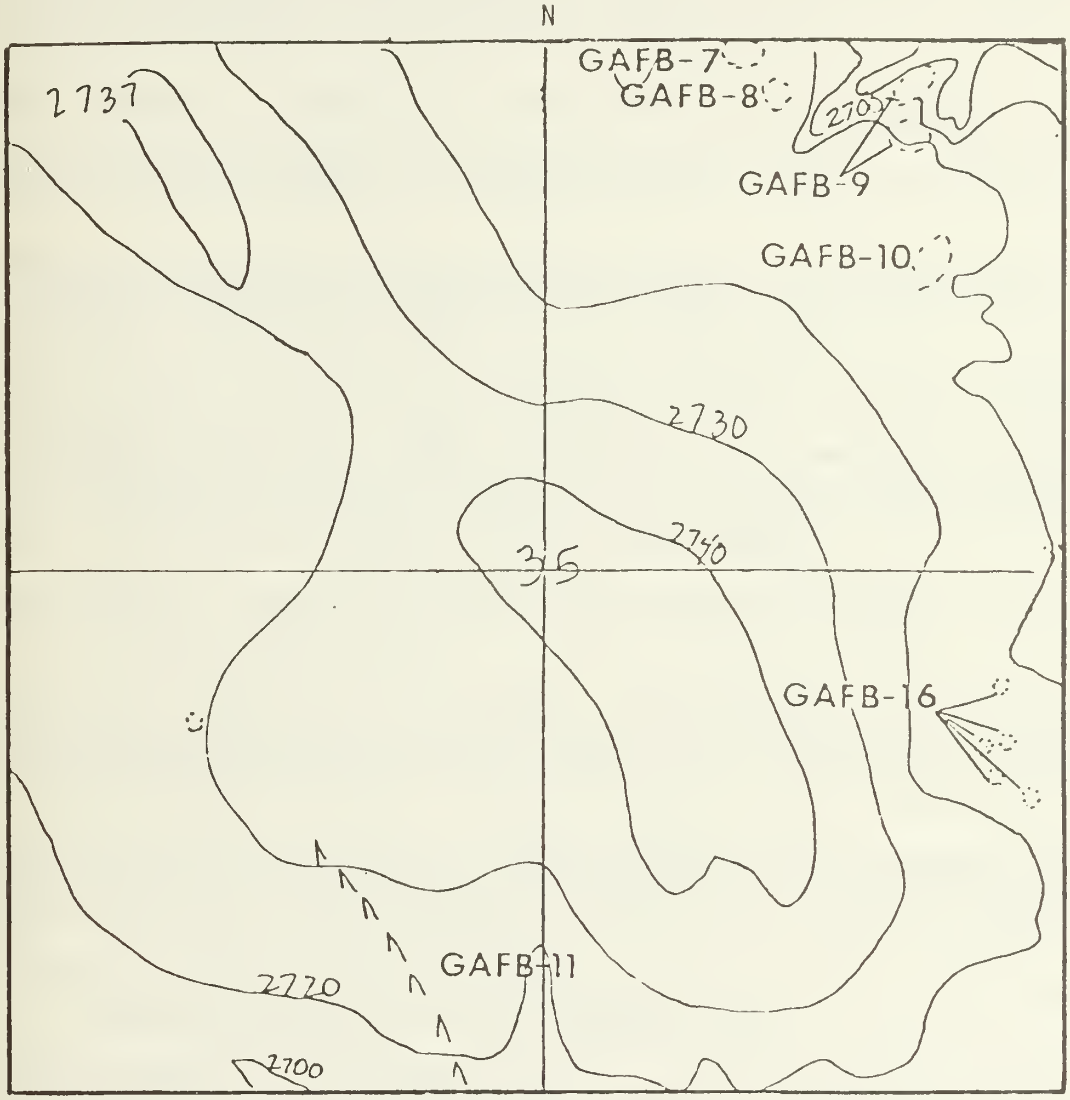
20. PHOTOGRAPH NO. ______

21. MAPS OF SITE ______

RECORDED BY Steve Aaberg DATE September 25, 1978.

STATE Montana COUNTY Valley SITE NAME ______ SITE NO. ______

SITE NO.________________ MAPPED BY________________ DATE________________



SCALE________________

When Entire Square Represents a Section, 1" = 1000'

22. APPROACH TO SITE:

23. REMARKS:

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